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Northern Periphery Programme 2007–2013
Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

ROADEX Research and eLearning Packgage:

Drainage

Timo Saarenketo, PhD
Roadscanners

Contents:

History of Drainage Research in ROADEX Projects 1998 - 2012

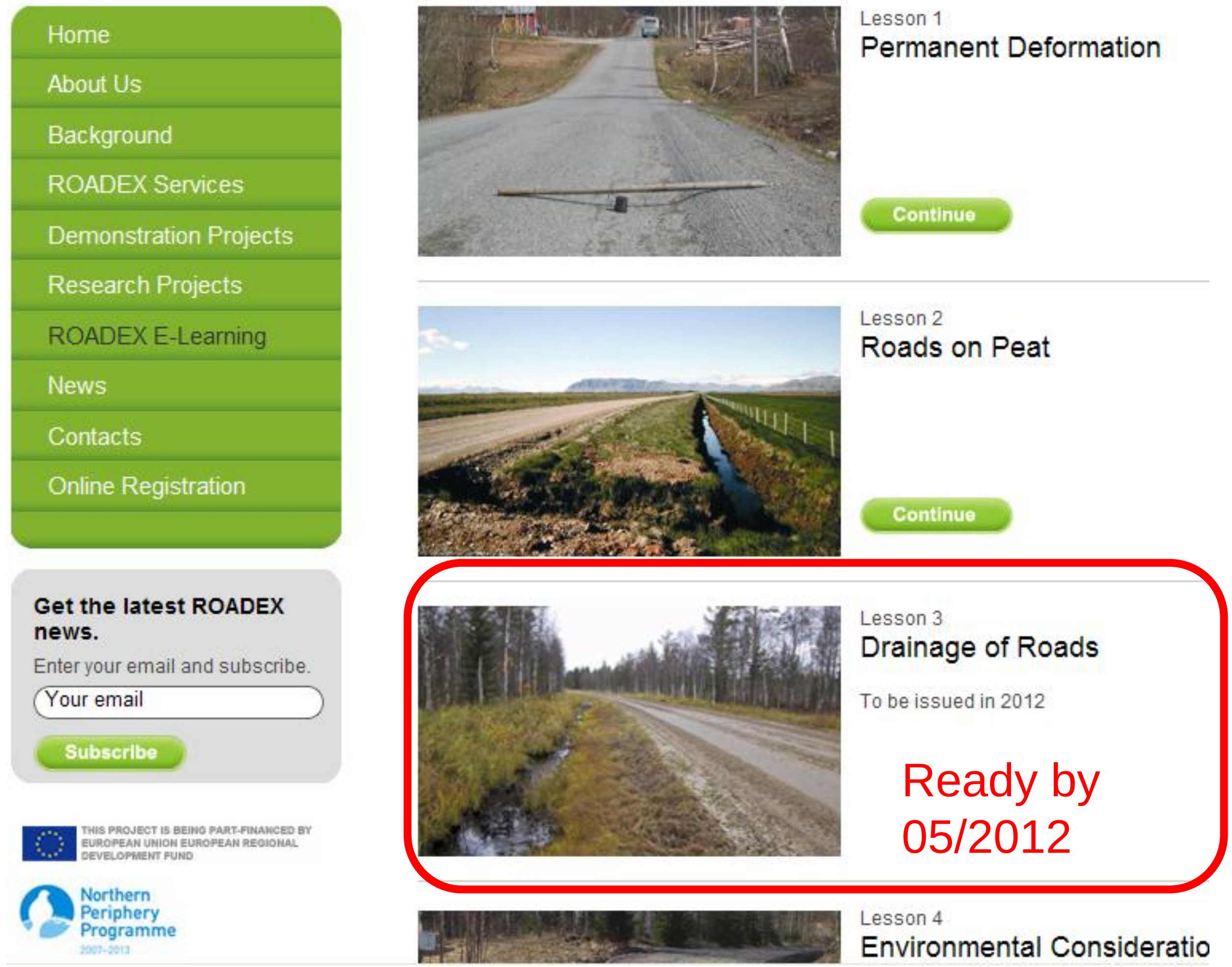
- Benchmarking: Drainage was of the biggest road condition management problems shared by all partners

- Drainage research: Identifying critical drainage sections, modelling drainage and pavement life time

- Development and testing drainage field survey techniques, drainage classification, drainage procurement documents in maintennace contracts

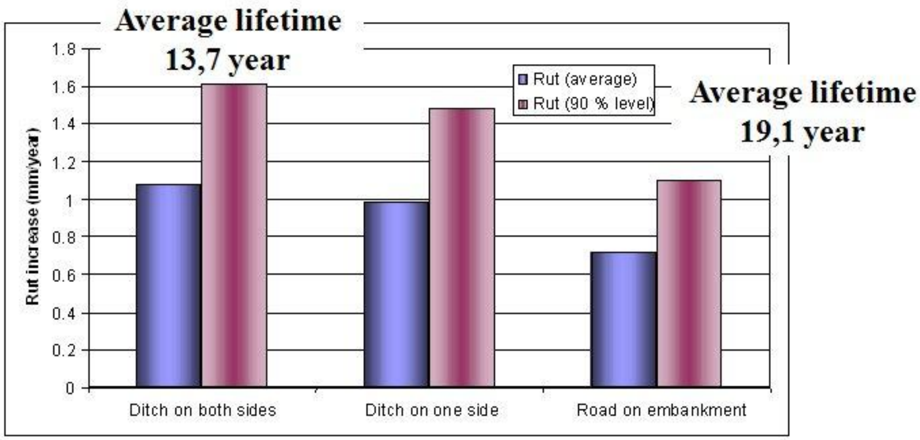
- Implementation: Drainage demonstration projects in partner areas, testing new techniques, drainage maintenace follow up, Drainage eLearning packages

Drainage eLearning Package



Drainage eLearning Package - Contents

1. Introduction, why drainage is important



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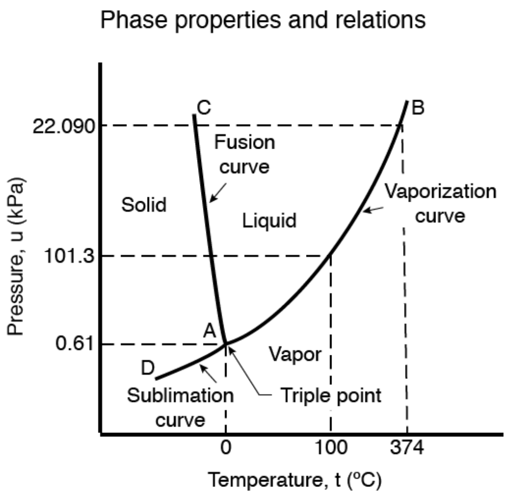
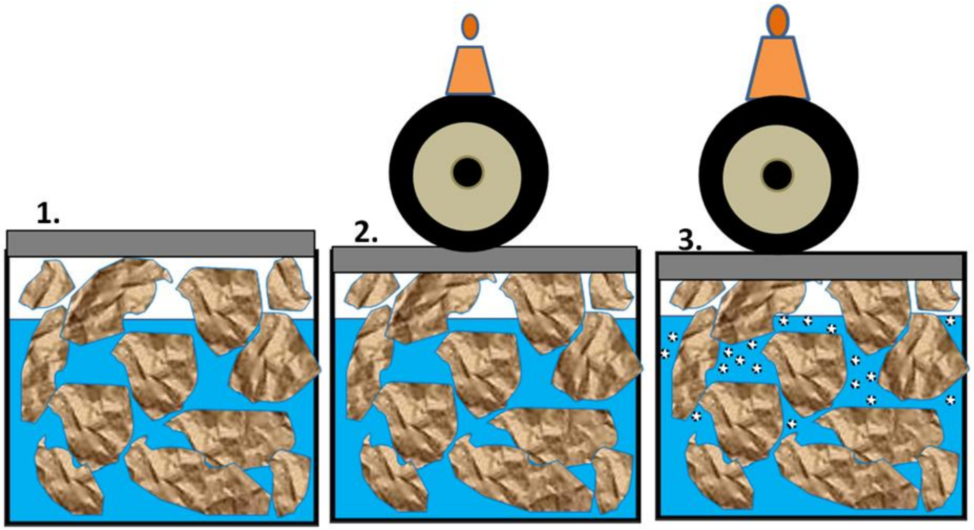
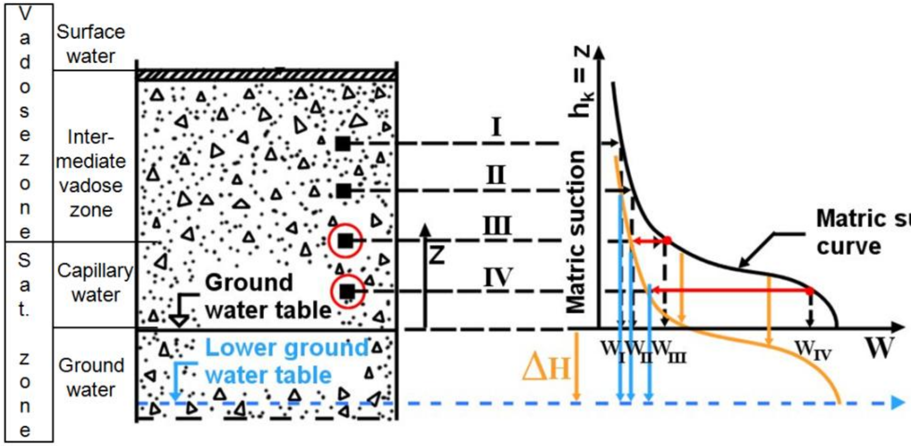
Drainage eLearning Package - Contents

2. Water in Road Materials and Subgrade Soils

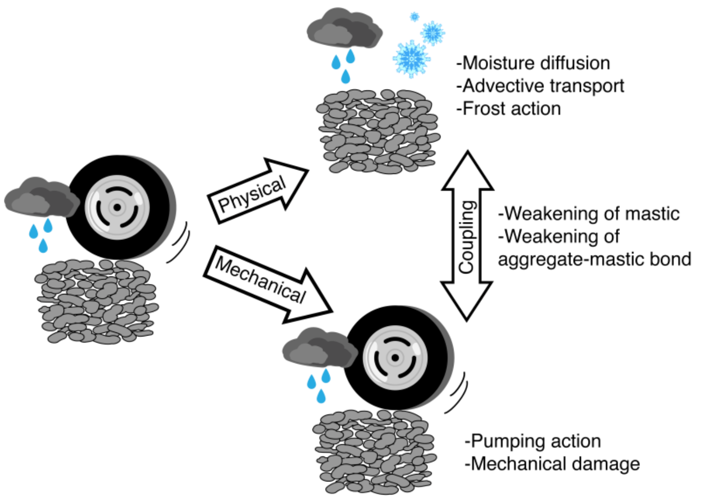


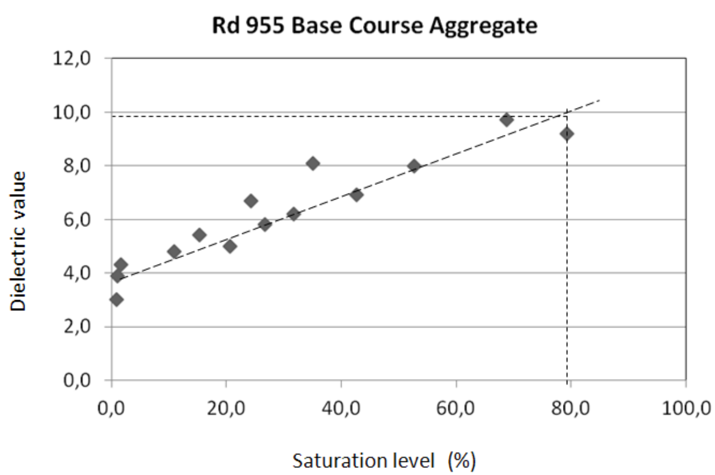


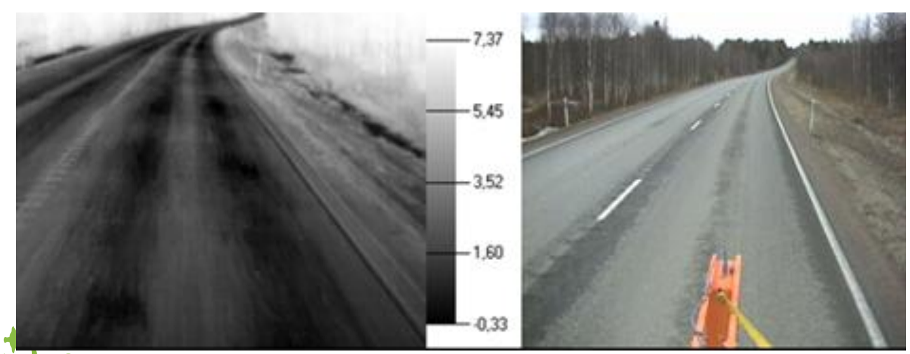


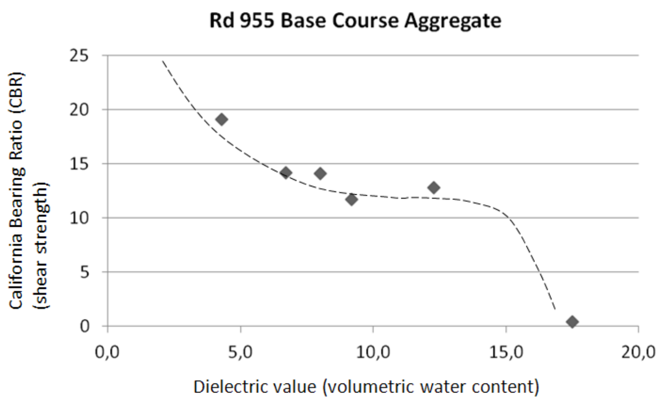
Drainage eLearning Package - Contents

3. Water and Mechanical Properties of Roads



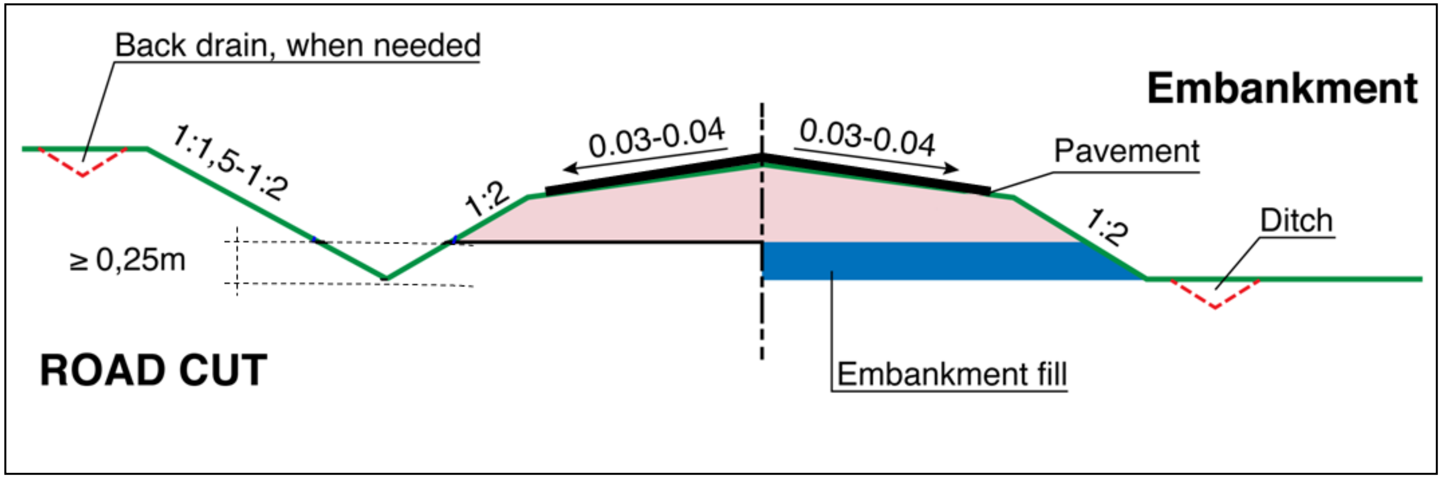


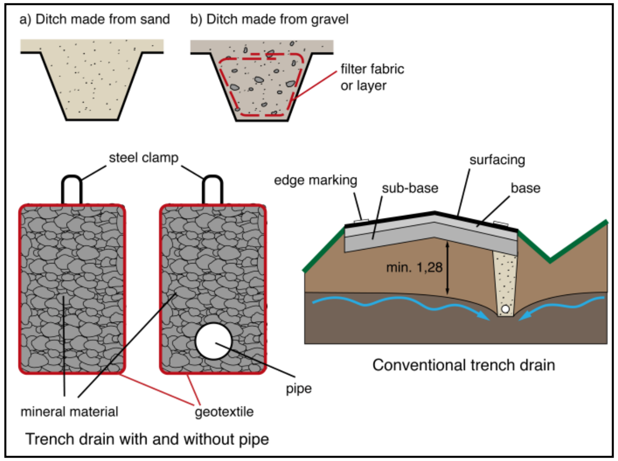


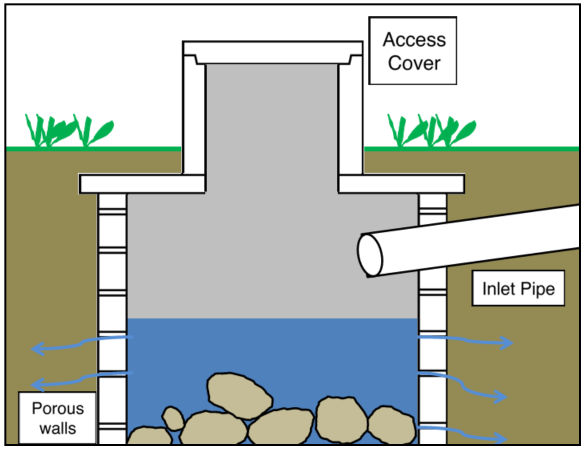


Drainage eLearning Package - Contents

4. Components of Road Drainage Systems

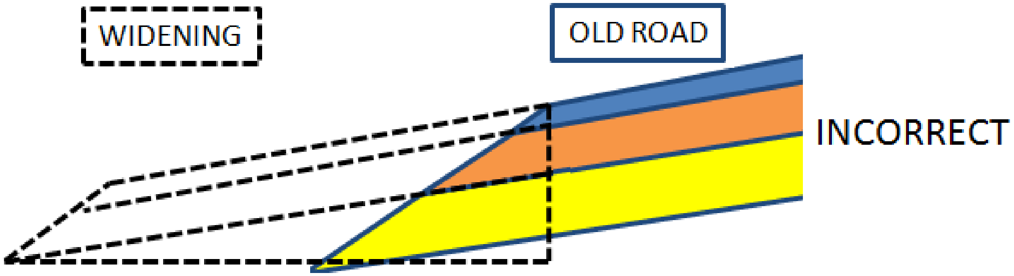






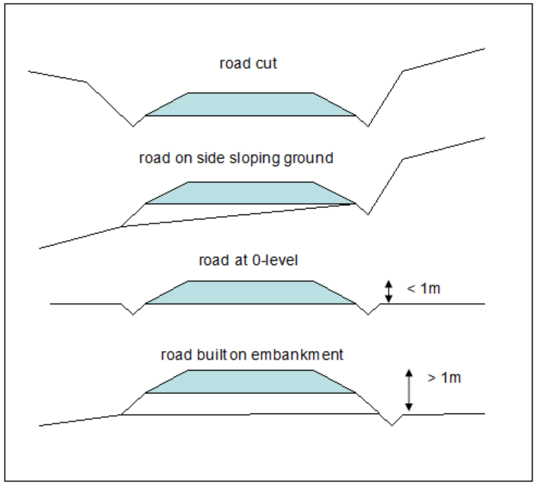
Drainage eLearning Package - Contents

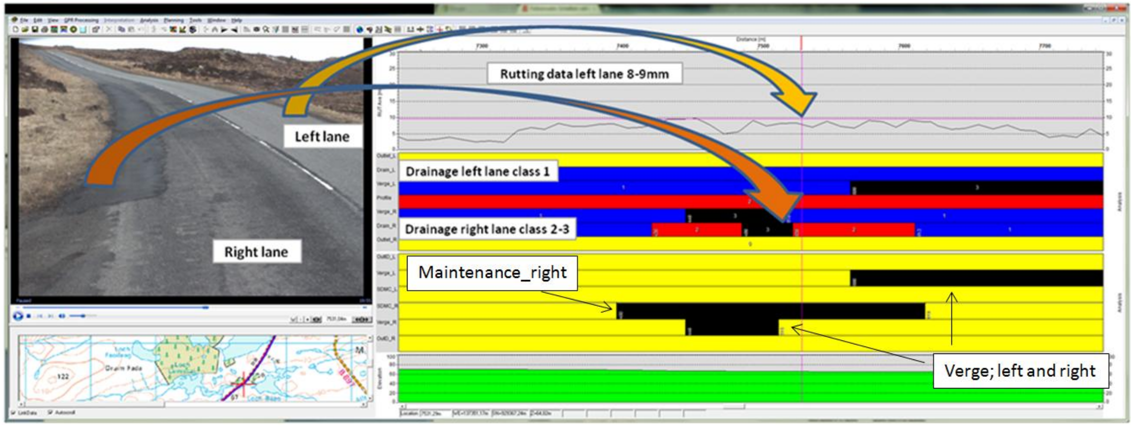
5. Drainage Problems and How to Avoid them



Drainage eLearning Package - Contents

6. Drainage Analysis and Classification





Drainage eLearning Package - Contents

7. Examples of Drainage Deficiences in ROADEX Area

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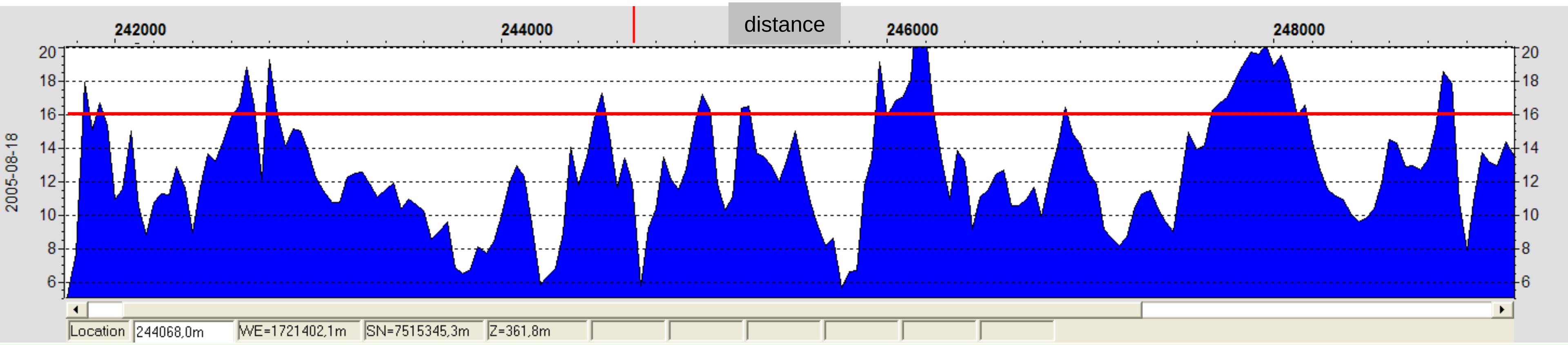
Economic Importance of a Good Drainage System

What is Pavement Life Time ?

• *rehabilitation measures needs to be taken when more than 10 % of the rutting or roughness values are higher than the trigger value*

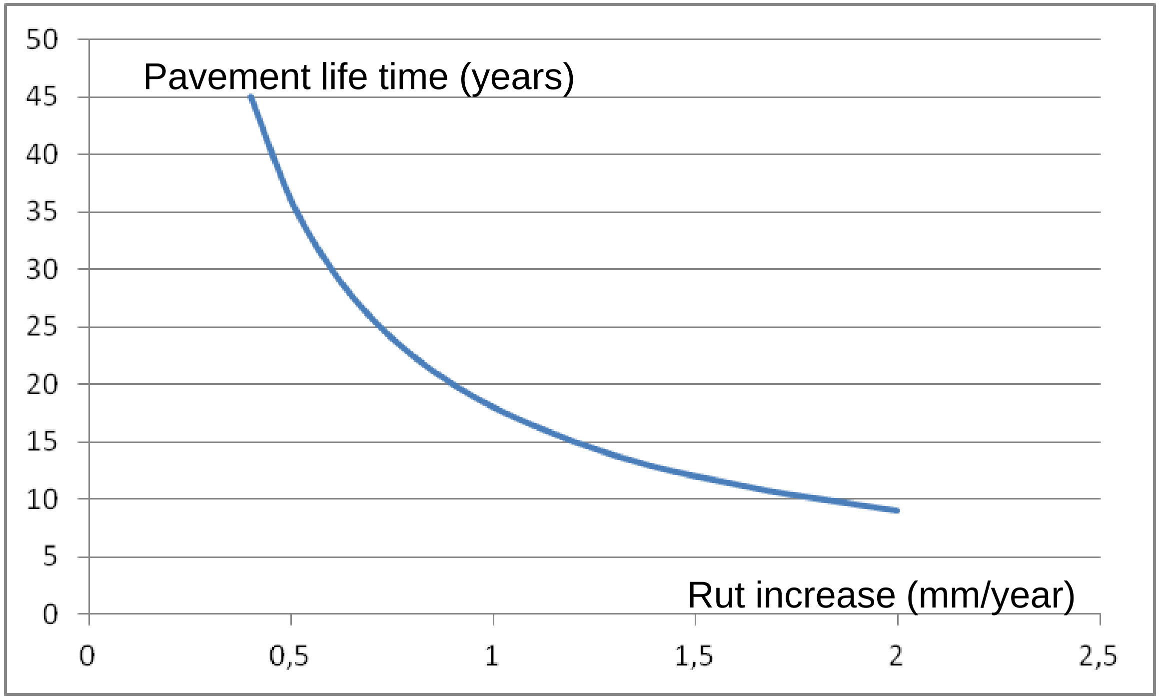
What is Common for these critical sections ?



Critical Parameters in Pavement Life Time Evaluation are Rut and IRI Growth Speed

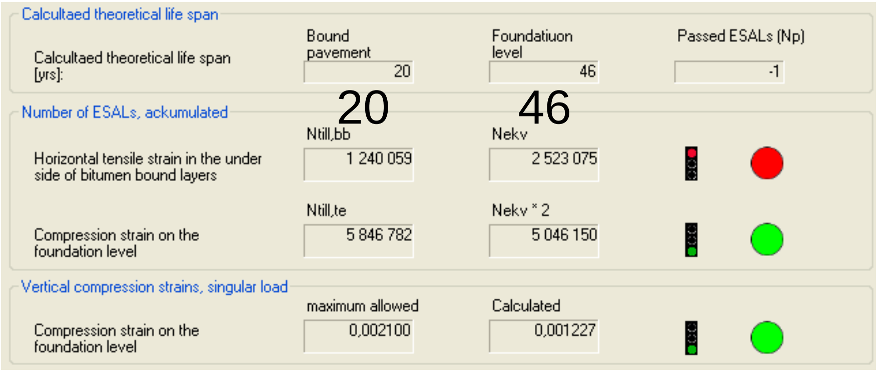
Rut increase (mm/year	Initial rut (mm)	Life time years	rut depth max(mm)
0,4	2	45	20
0,5	2	36	20
0,6	2	30	20
0,7	2	25,7	20
0,8	2	22,5	20
0,9	2	20	20
1	2	18	20
1,1	2	16,4	20
1,2	2	15	20
1,3	2	13,8	20
1,4	2	12,8	20
1,5	2	12	20
1,6	2	11,3	20
1,7	2	10,6	20
1,85	2	9,8	20
2	2	9	20



But pavement life time can be also calculated using linear elastic theory

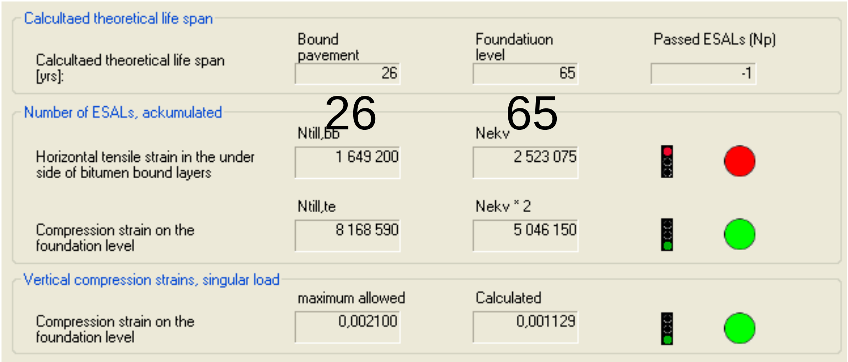
PMS Objekt Pavement Life Time Calculations – Good Drainage

Bound: 80
Unbound base old: 250 mm
Unbound sub base old: 150 mm
Filter course: 220 mm
Structures: total: 700 mm
Subgrade: moraine
Drainage: Ok



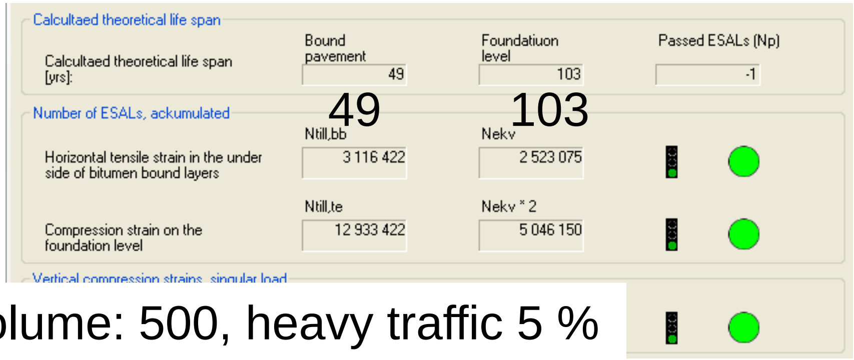
Rut Increase: 0,9 mm/year

Bound: 100
Unbound base old: 250 mm
Unbound sub base old: 150 mm
Filter course: 220 mm
Structures: total: 720 mm
Subgrade: moraine
Drainage: Ok



Rut Increase: 0,7 mm/year

Bound: 120
Unbound base old: 250 mm
Unbound sub base old: 150 mm
Filter course: 220 mm
Structures: total: 740 mm
Subgrade: moraine
Drainage: Ok

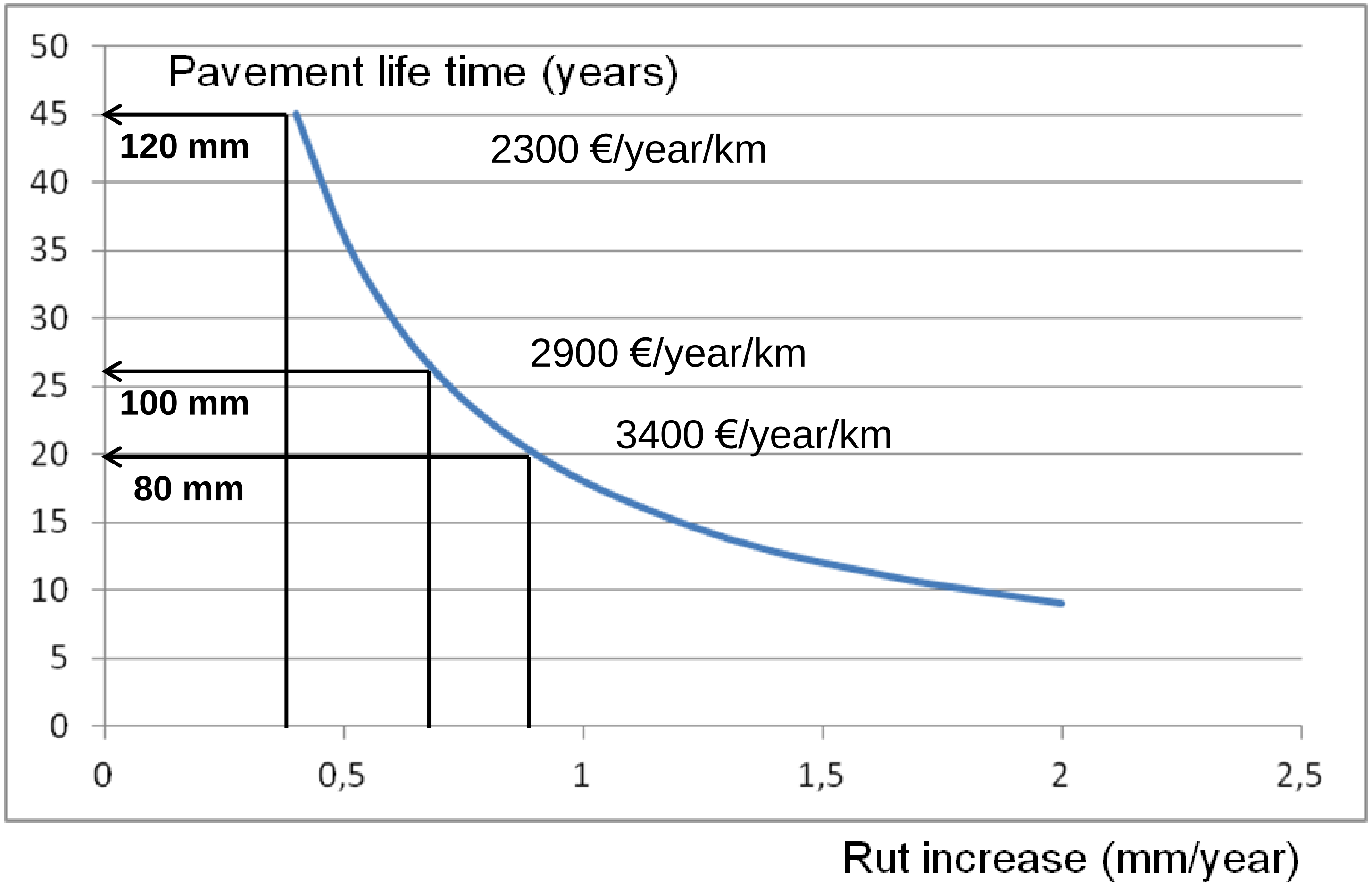


Rut Increase: 0,4 mm/year

Traffic volume: 500, heavy traffic 5 %

Drainage and Linear Elastic Behaviour of Pavement Structure

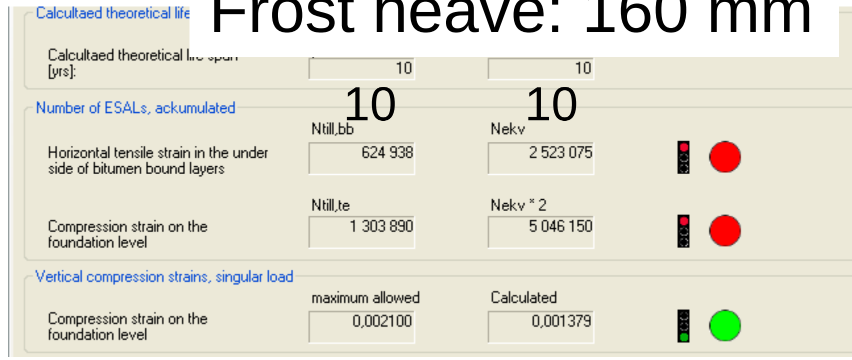
Case: Drainage in Good Condition



PMS Objekt Pavement Life Time Calculations – Poor Drainage

Bound: 80
Unbound base old: 250 mm
Unbound sub base old: 150 mm
Filter course: 220 mm
Structures: total: 700 mm
Subgrade: moraine
Drainage: class 3

Frost heave: 160 mm



Calcultaed theoretical life span

Calcultaed theoretical life span [yrs]:	10	10

Number of ESALs, ackumulated

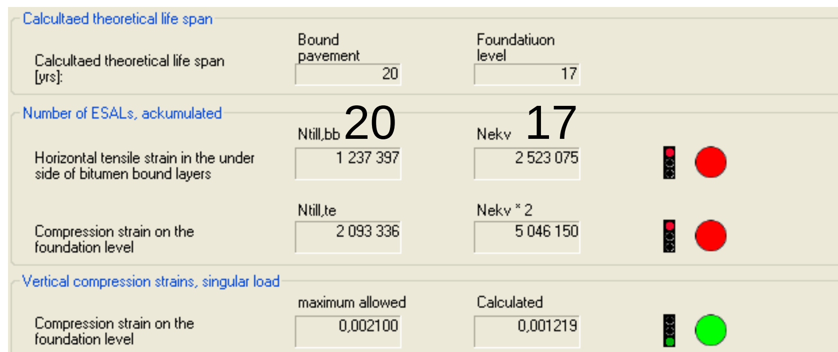
	Ntill,bb	Nekv
Horizontal tensile strain in the under side of bitumen bound layers	624 938	2 523 075
	Ntill,te	Nekv * 2
Compression strain on the foundation level	1 303 890	5 046 150

Vertical compression strains, singular load

	maximum allowed	Calculated
Compression strain on the foundation level	0,002100	0,001379

Rut Increase: 1,85 mm/year

Bound: 100
Unbound base old: 250 mm
Unbound sub base old: 150 mm
Filter course: 220 mm
Structures: total: 720 mm
Subgrade: moraine
Drainage: class 3



Calcultaed theoretical life span

	Bound pavement	Foundatiuon level
Calcultaed theoretical life span [yrs]:	20	17

Number of ESALs, ackumulated

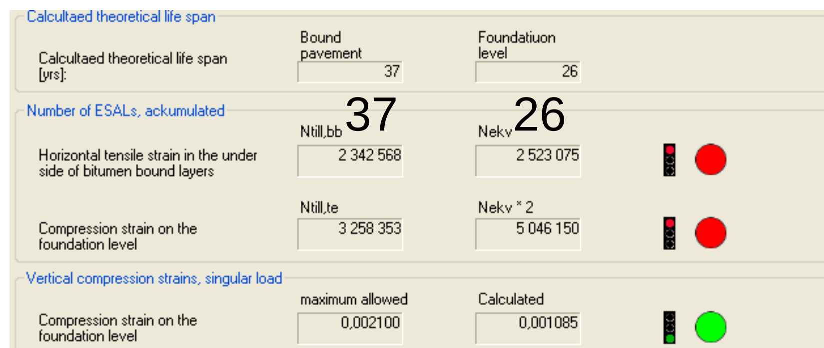
	Ntill,bb	Nekv
Horizontal tensile strain in the under side of bitumen bound layers	1 237 397	2 523 075
	Ntill,te	Nekv * 2
Compression strain on the foundation level	2 093 336	5 046 150

Vertical compression strains, singular load

	maximum allowed	Calculated
Compression strain on the foundation level	0,002100	0,001219

Rut Increase: 1,1 mm/year

Bound: 120
Unbound base old: 250 mm
Unbound sub base old: 150 mm
Filter course: 220 mm
Structures: total: 740 mm
Subgrade: moraine
Drainage: class 3



Calcultaed theoretical life span

	Bound pavement	Foundatiuon level
Calcultaed theoretical life span [yrs]:	37	26

Number of ESALs, ackumulated

	Ntill,bb	Nekv
Horizontal tensile strain in the under side of bitumen bound layers	2 342 568	2 523 075
	Ntill,te	Nekv * 2
Compression strain on the foundation level	3 258 353	5 046 150

Vertical compression strains, singular load

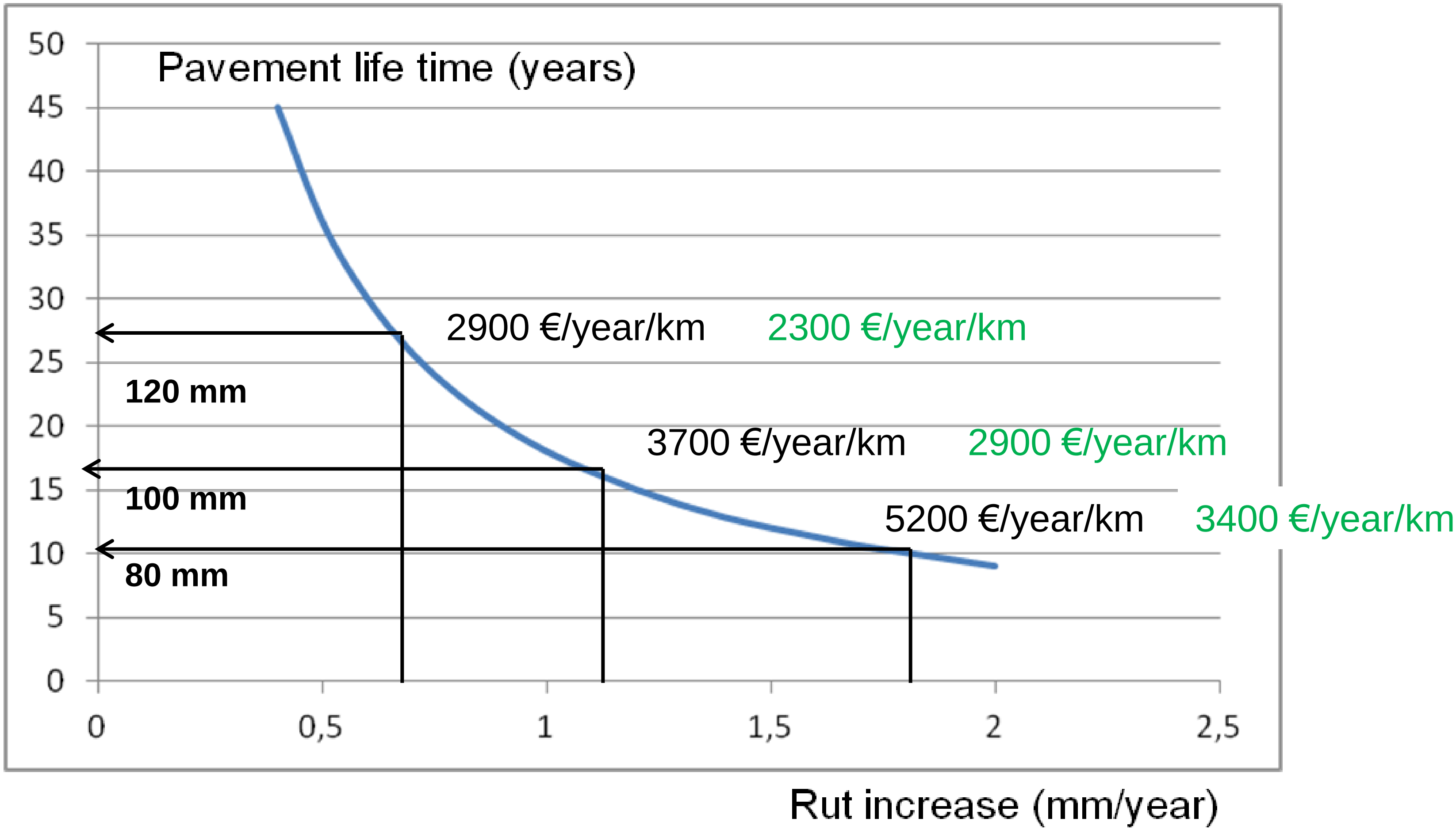
	maximum allowed	Calculated
Compression strain on the foundation level	0,002100	0,001085

Rut Increase: 0,7 mm/year

Traffic volume: 500, heavy traffic 5 %

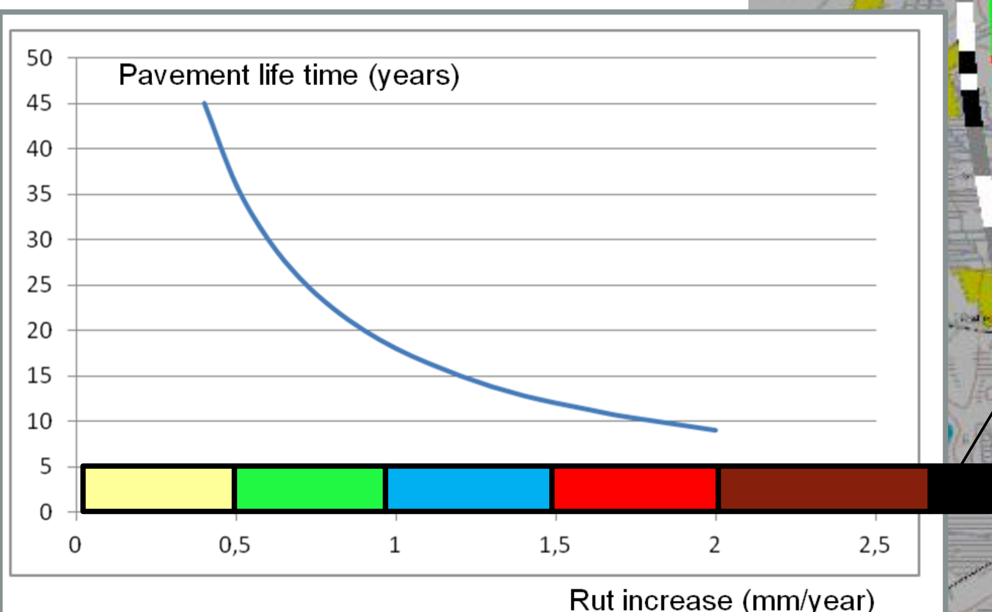
Drainage and Linear Elastic Behaviour of Pavement Structure

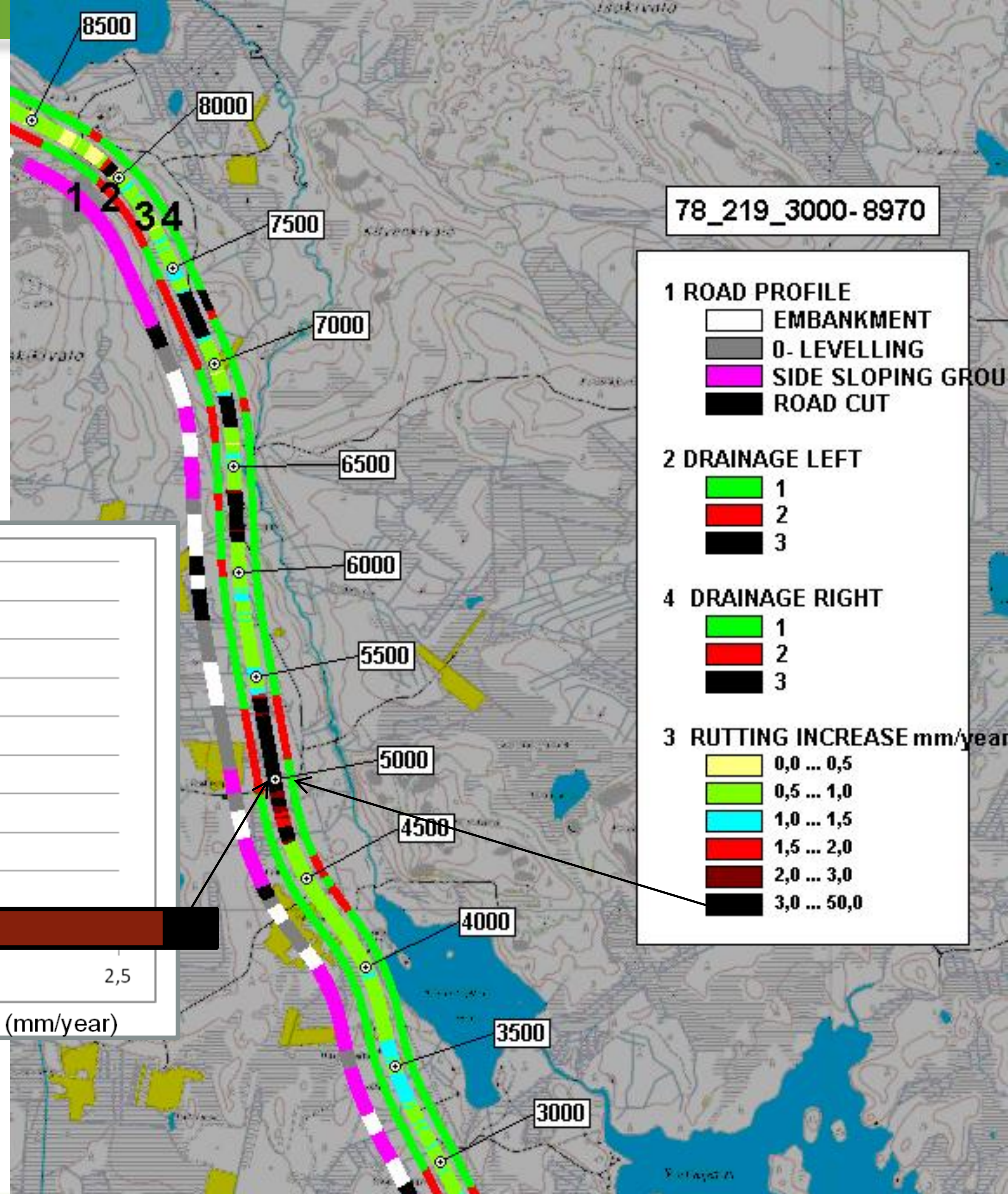
Case: Drainage in Poor Condition



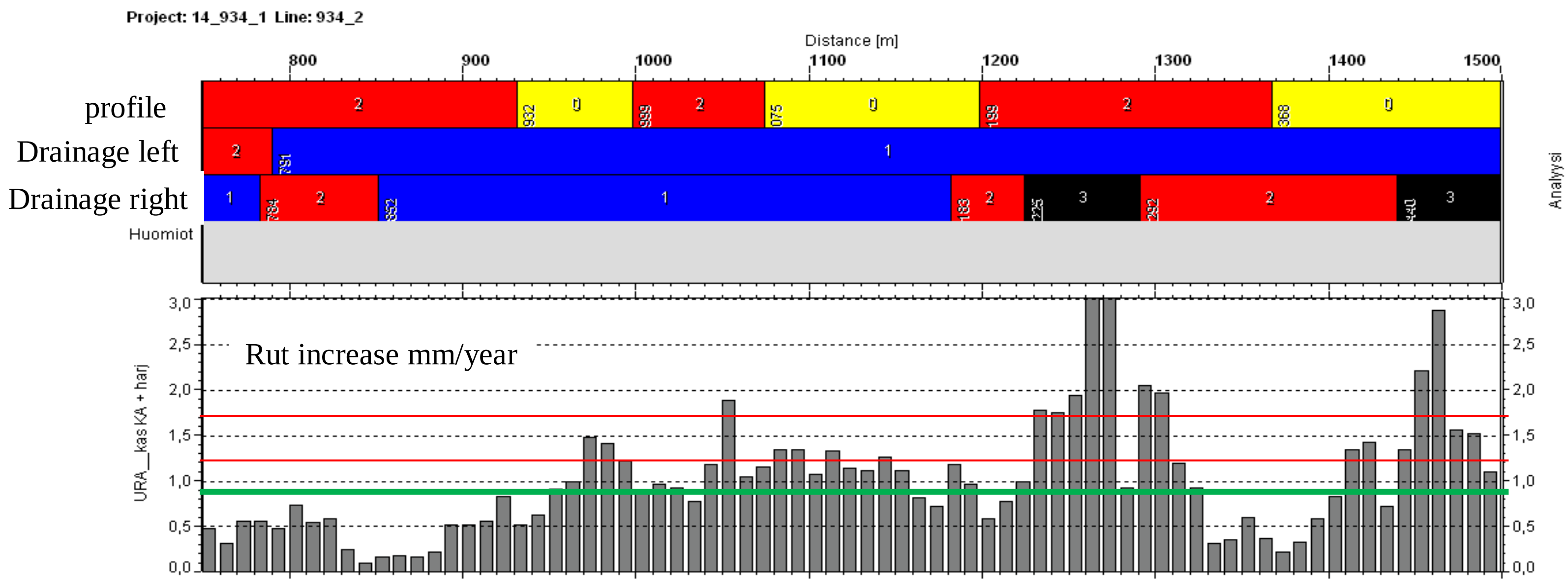
But, in additon to linear elastic fatique, poor drainage is causing permanent deformation!

Road 78 Section 219 Pavement Life Time





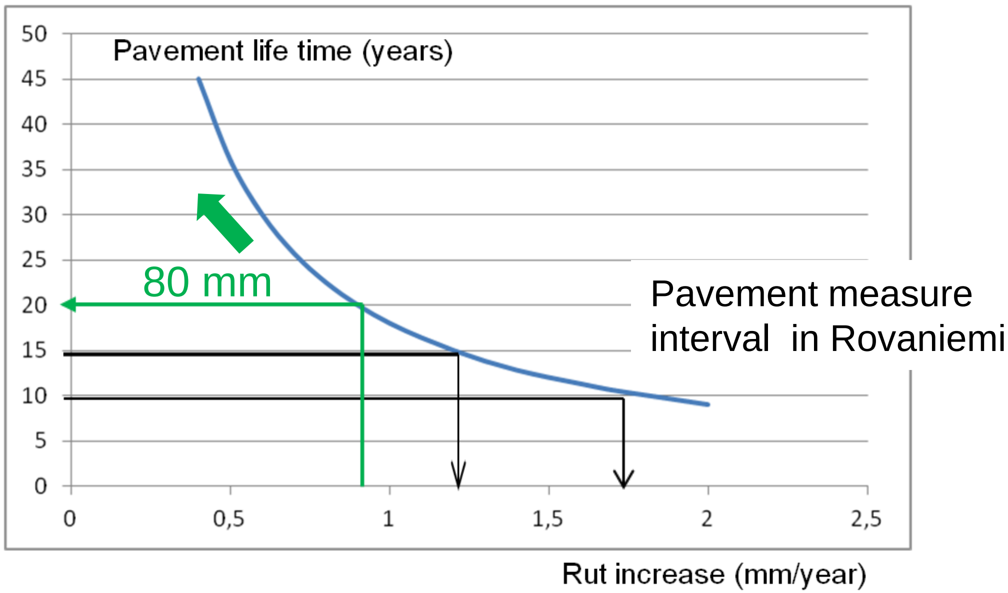
Investment to Better Drainage is Win-Win for Everyone



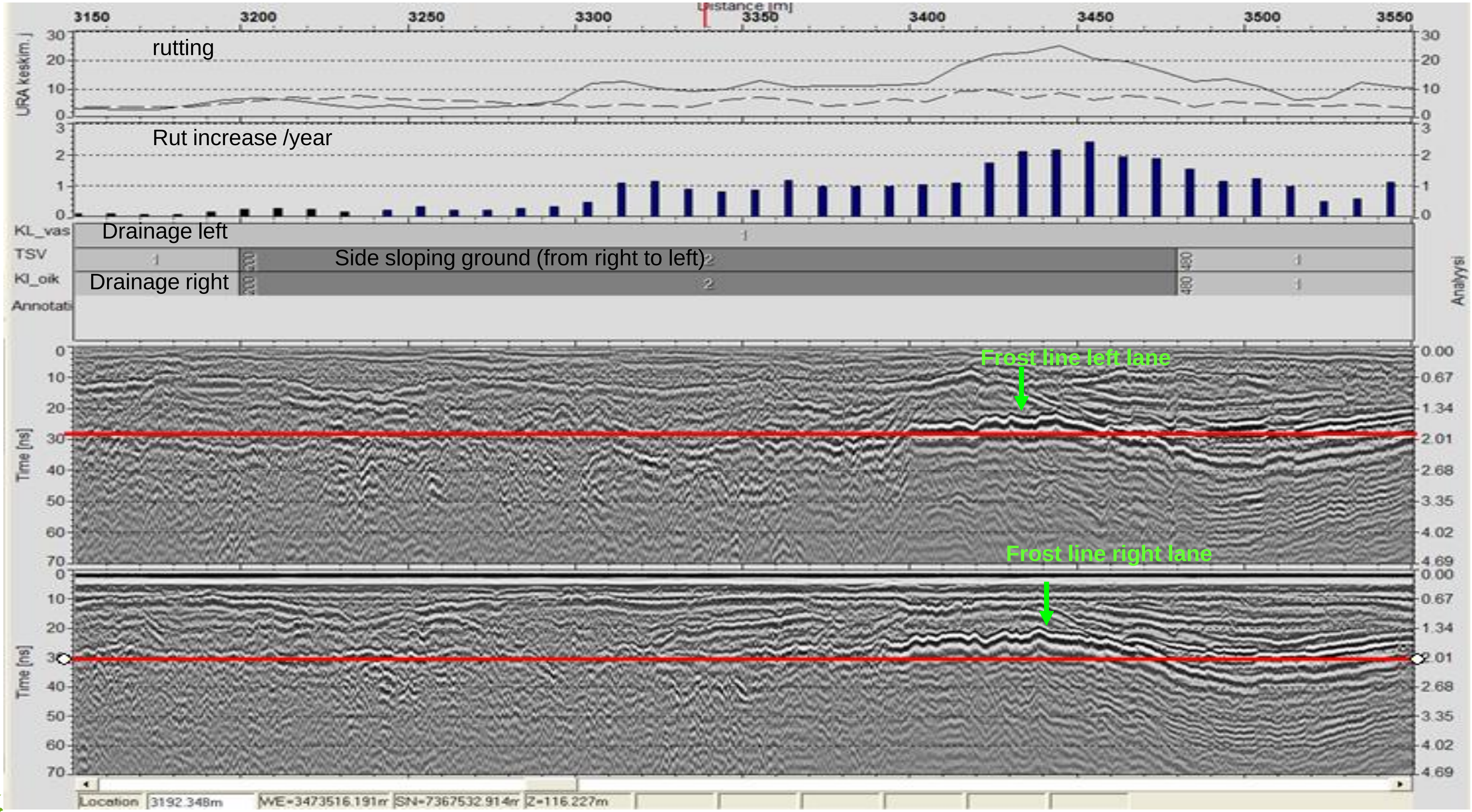
Rovaniemi area:
First year investments:
100 k€ =>
Potential savings:
250 – 330 k€/year

Further use of savings:

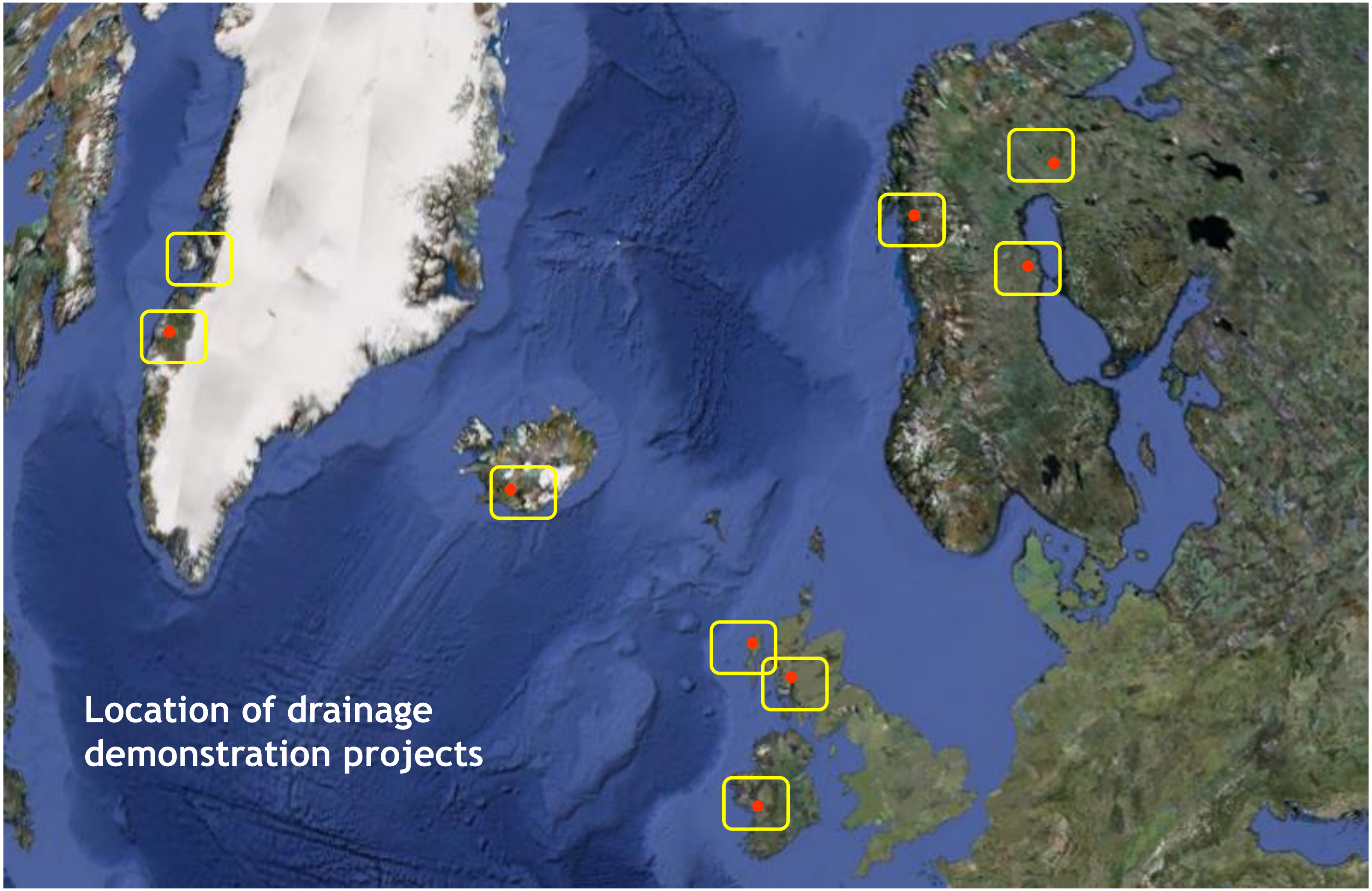
1. 50 k€: for drainage maintenance
2. 200- 330 k€: for thicker pavements



Drainage, Frost and Rutting: CaseRoad 81



The ROADEX demonstration projects - Drainage



DRAINAGE IMPLEMENTATION PROJECTS

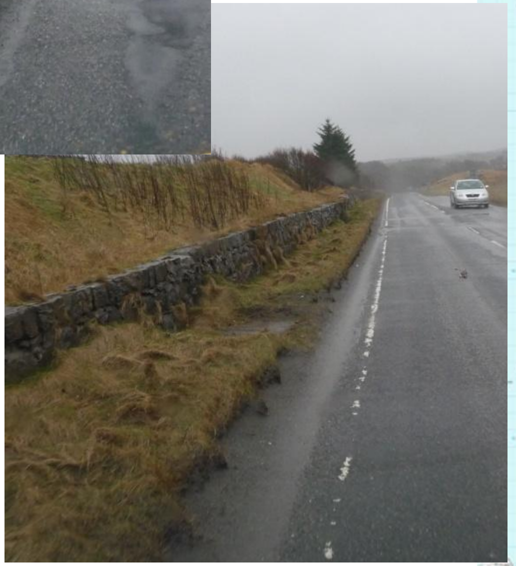
WESTERN ISLES

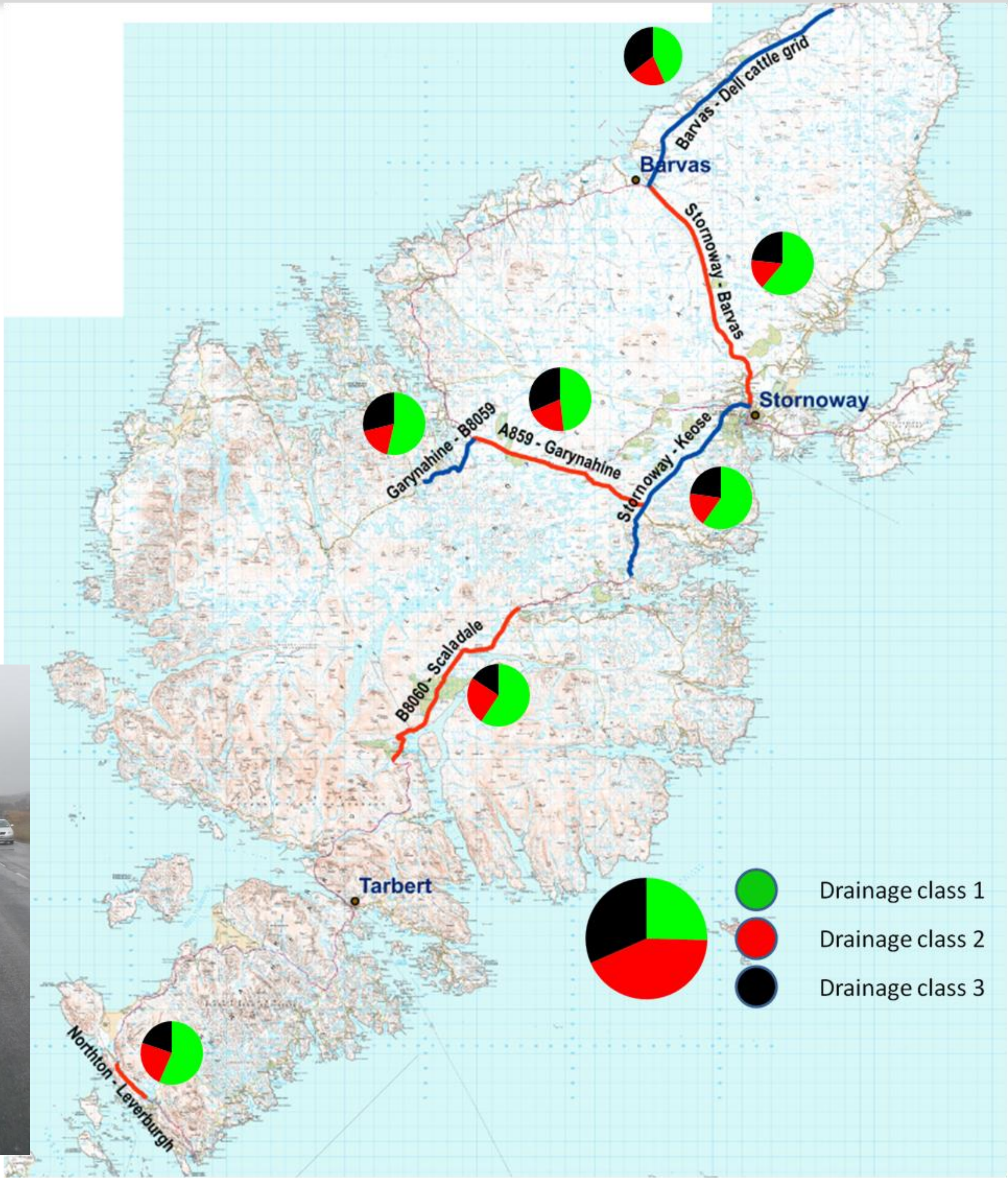
NORWAY

ICELAND

SISIMIUT, GREENLAND

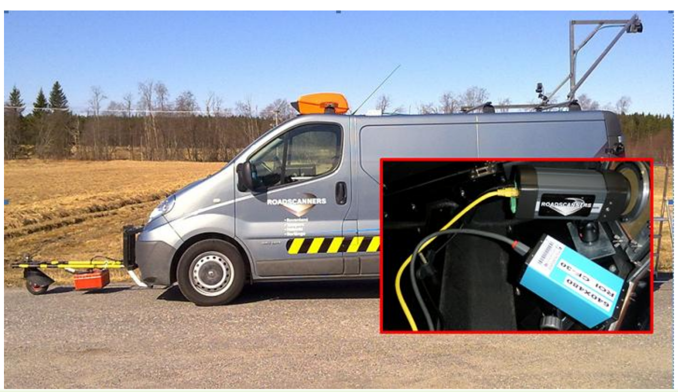
Drainage Condition in Western Isles

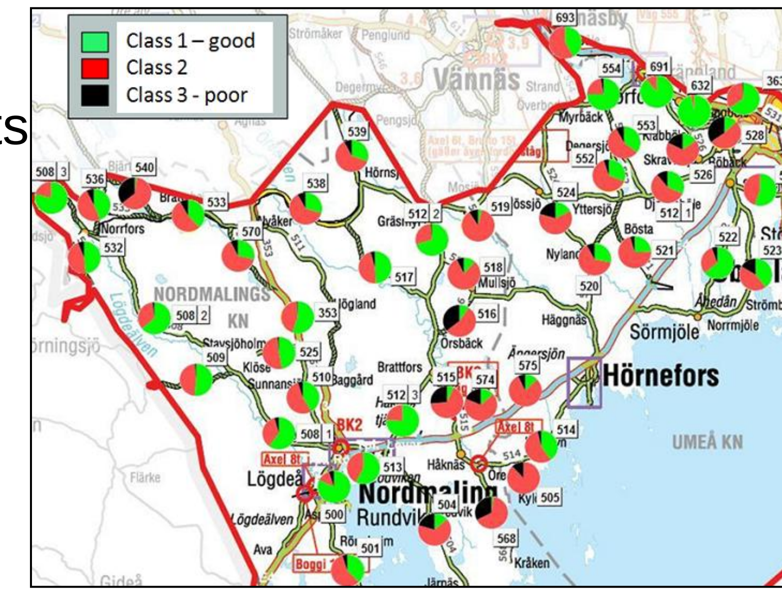




ROADEX Demonstration project:Umeå Södra, Region Norr, Sweden:

- Testing tools to improve drainage analysis in Umeå Södra maintenance area
  - Laser Scanner and GPR; combining road structure and ditch bottom depths
  - Drainage analysis – seasonal tests
  - Tools for outlet ditch inventory
  - Thermal camera development

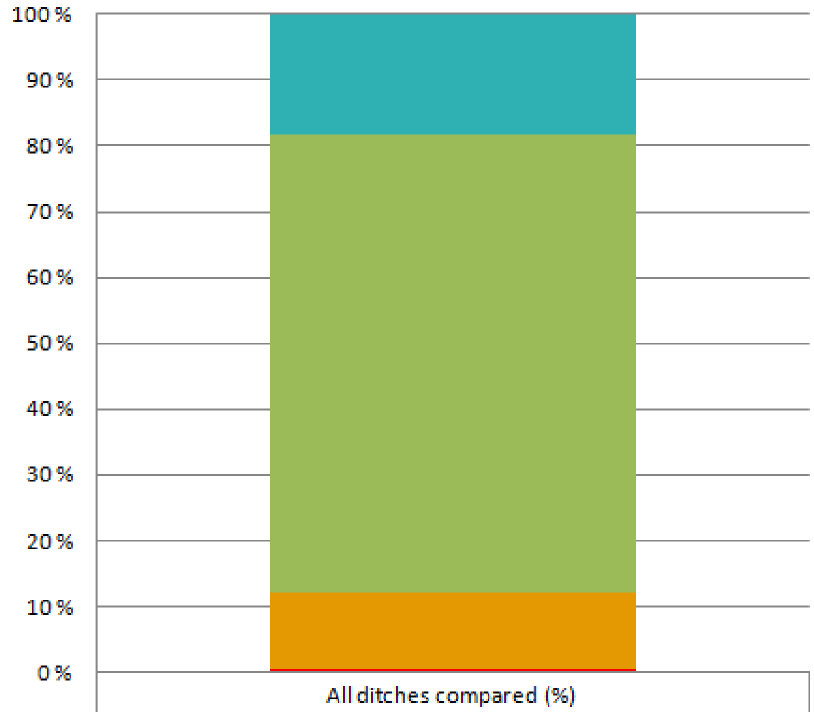




SEASONAL TESTS FOR DRAINAGE ANALYSIS

Drainage analysis in a) spring, b) fall

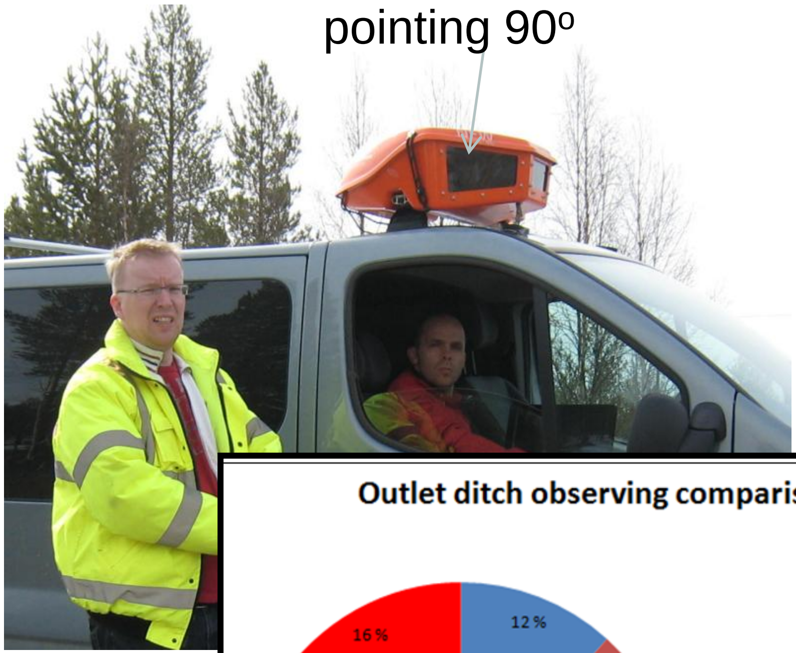
Results:
Drainage analysis can be done both in spring and in fall

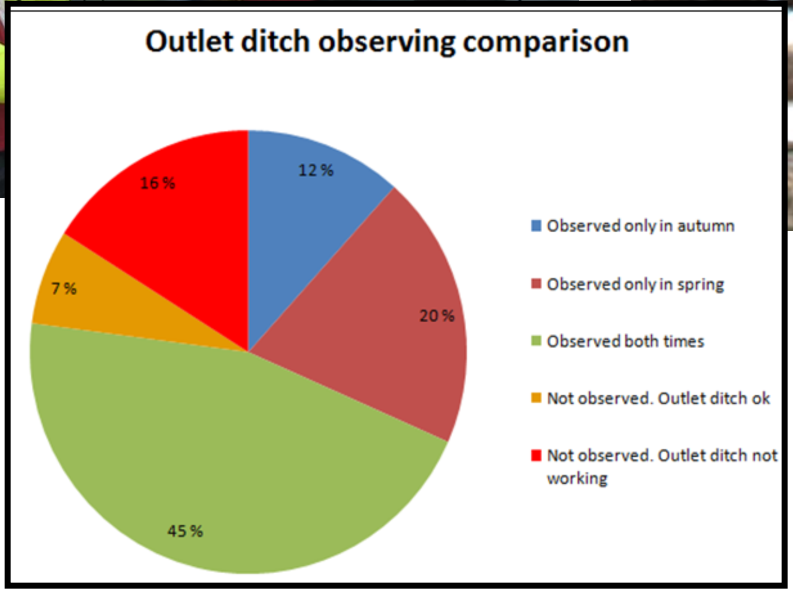


	All ditches compared (%)
Significantly better in spring	0,1
Slightly better in spring	18,1
Same classification	69,8
Slightly worse in spring	11,6
Significantly worse in spring	0,4

Road Doctor Cam Link for Outlet Ditches

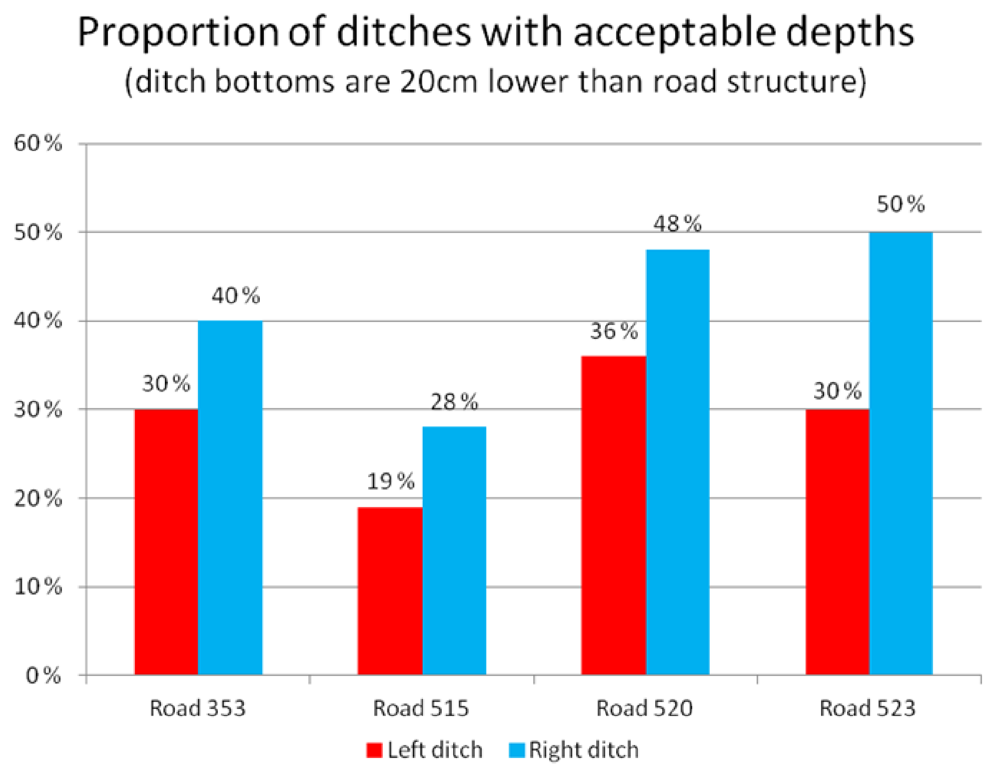
Video camera
pointing 90º

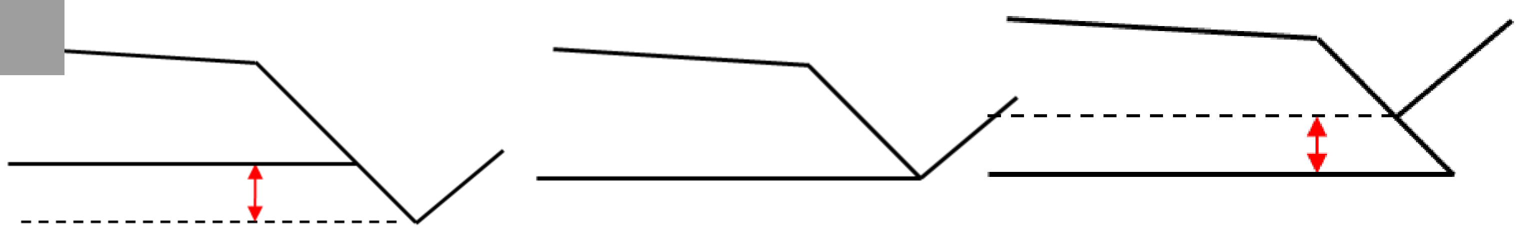




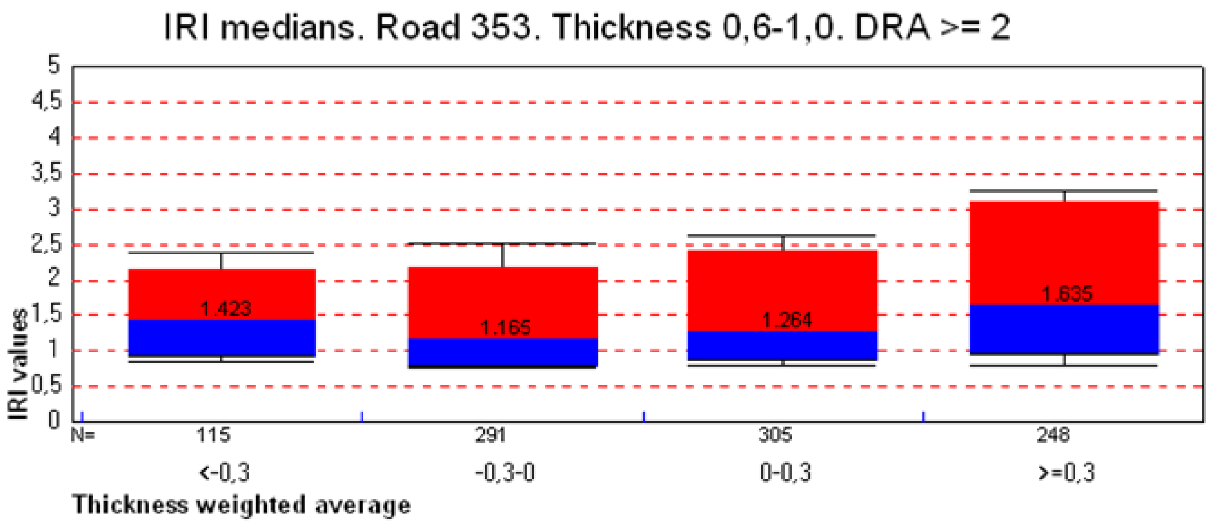
Still image

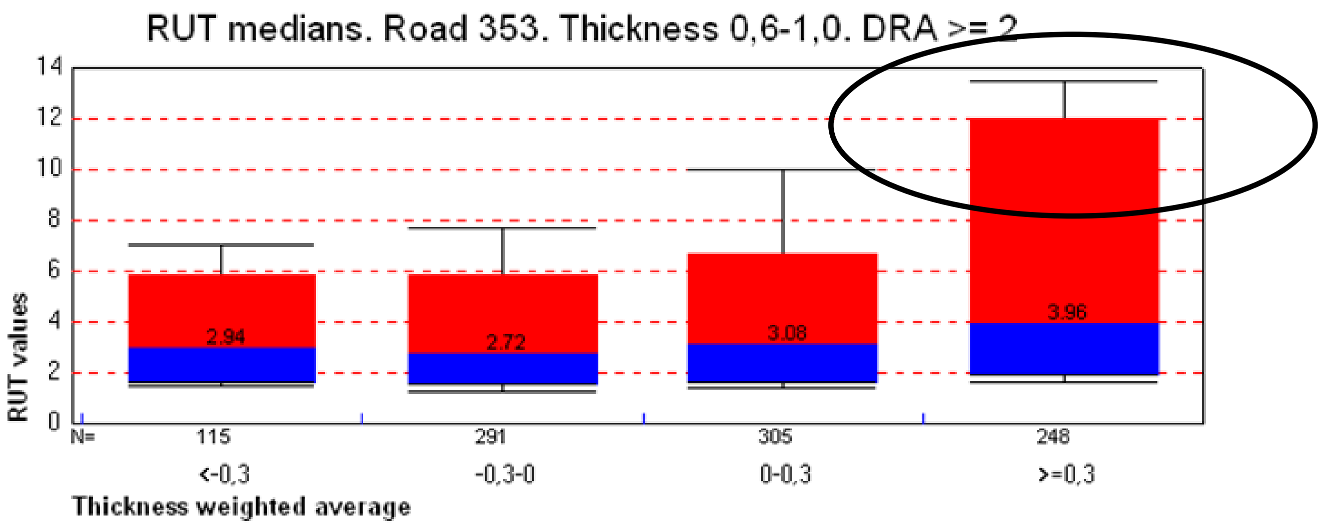
Ditch Depths with Laser Scanner and GPR





Problems with Shallow Ditch Depths are Reflected also in IRI and Rut Depth Values





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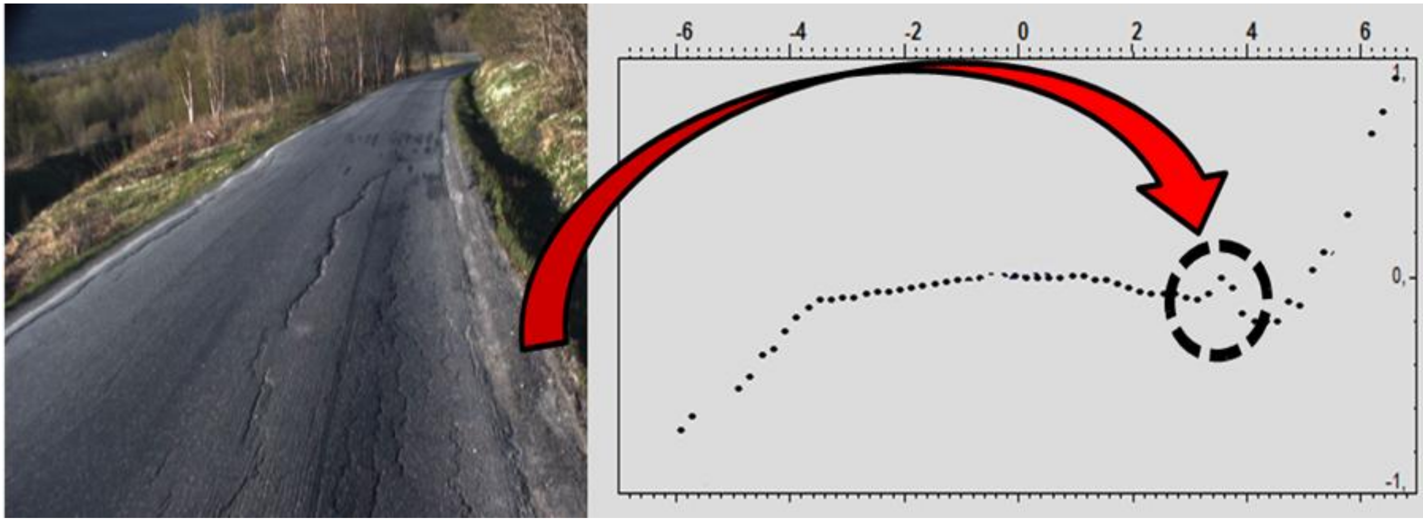
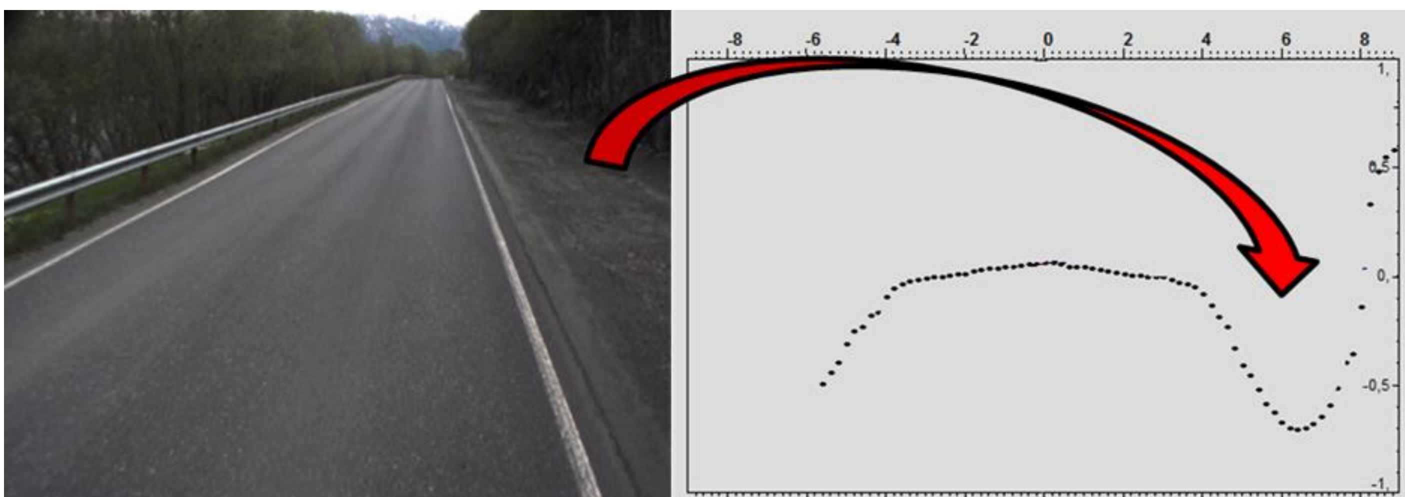
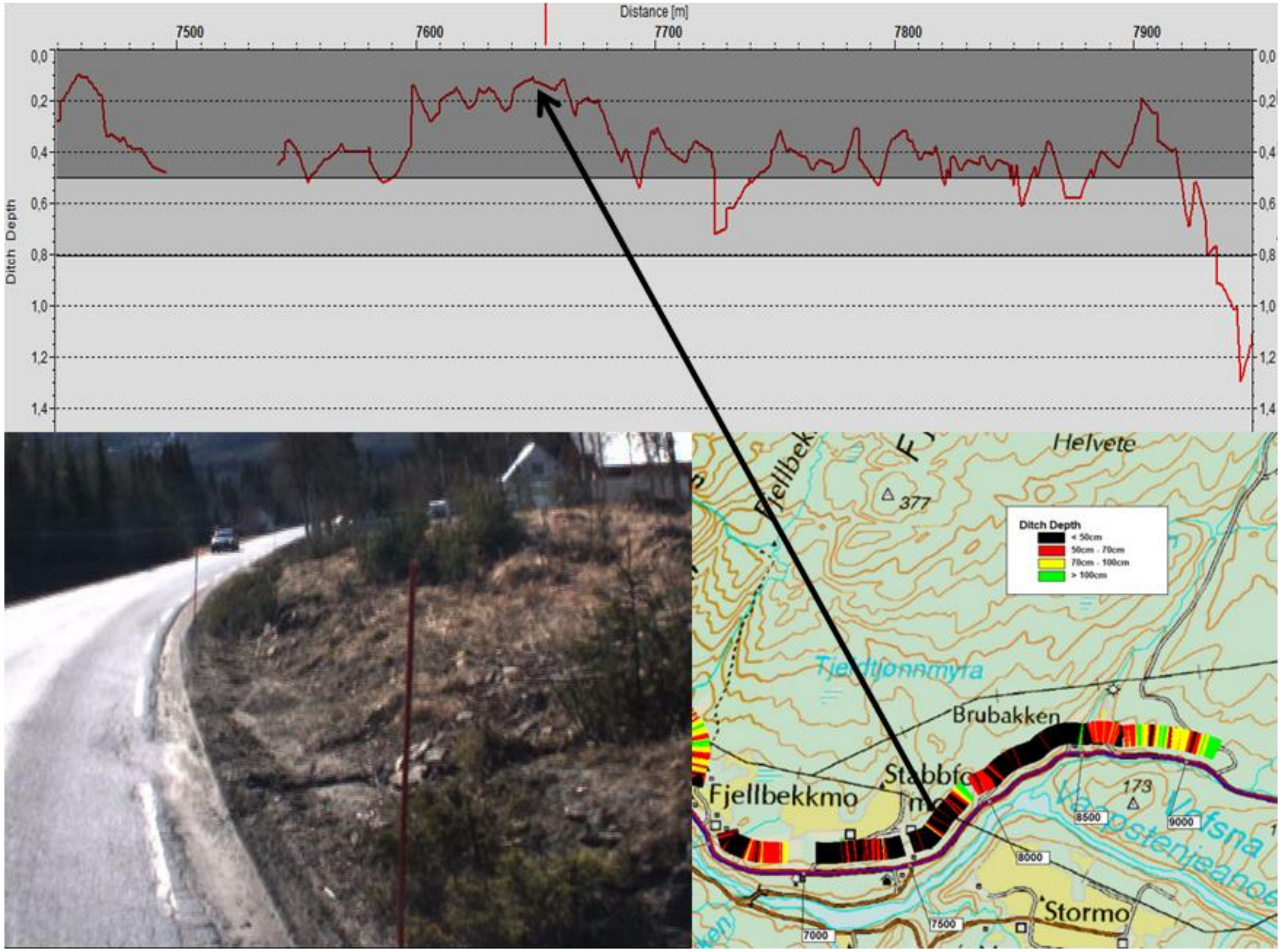
Drainage Examples from Norway





Ditch Bottom Level Anaslysis Rd 73 Norway



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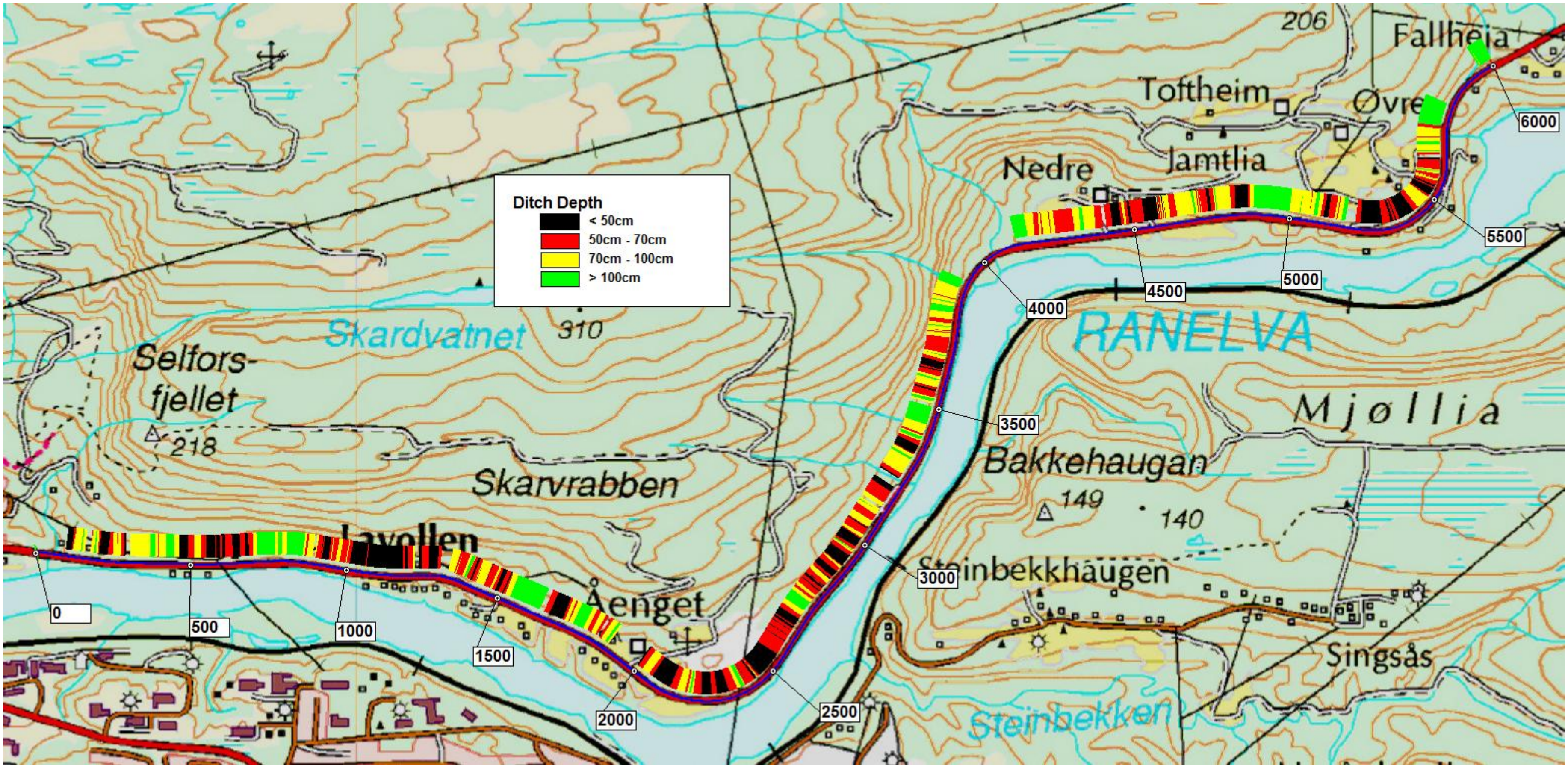
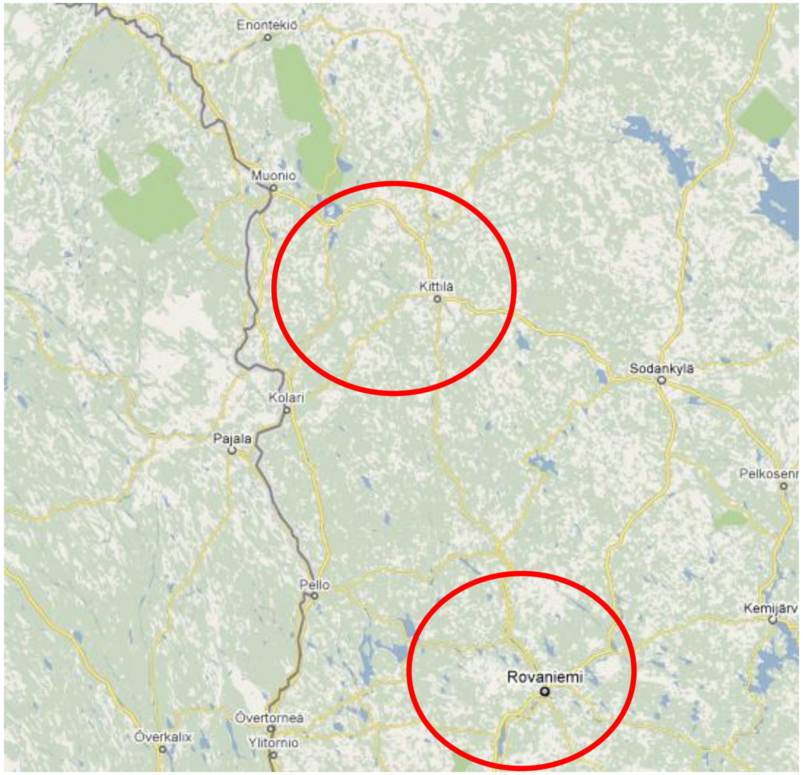
Ditch Bottom Level Map: E6, section 12



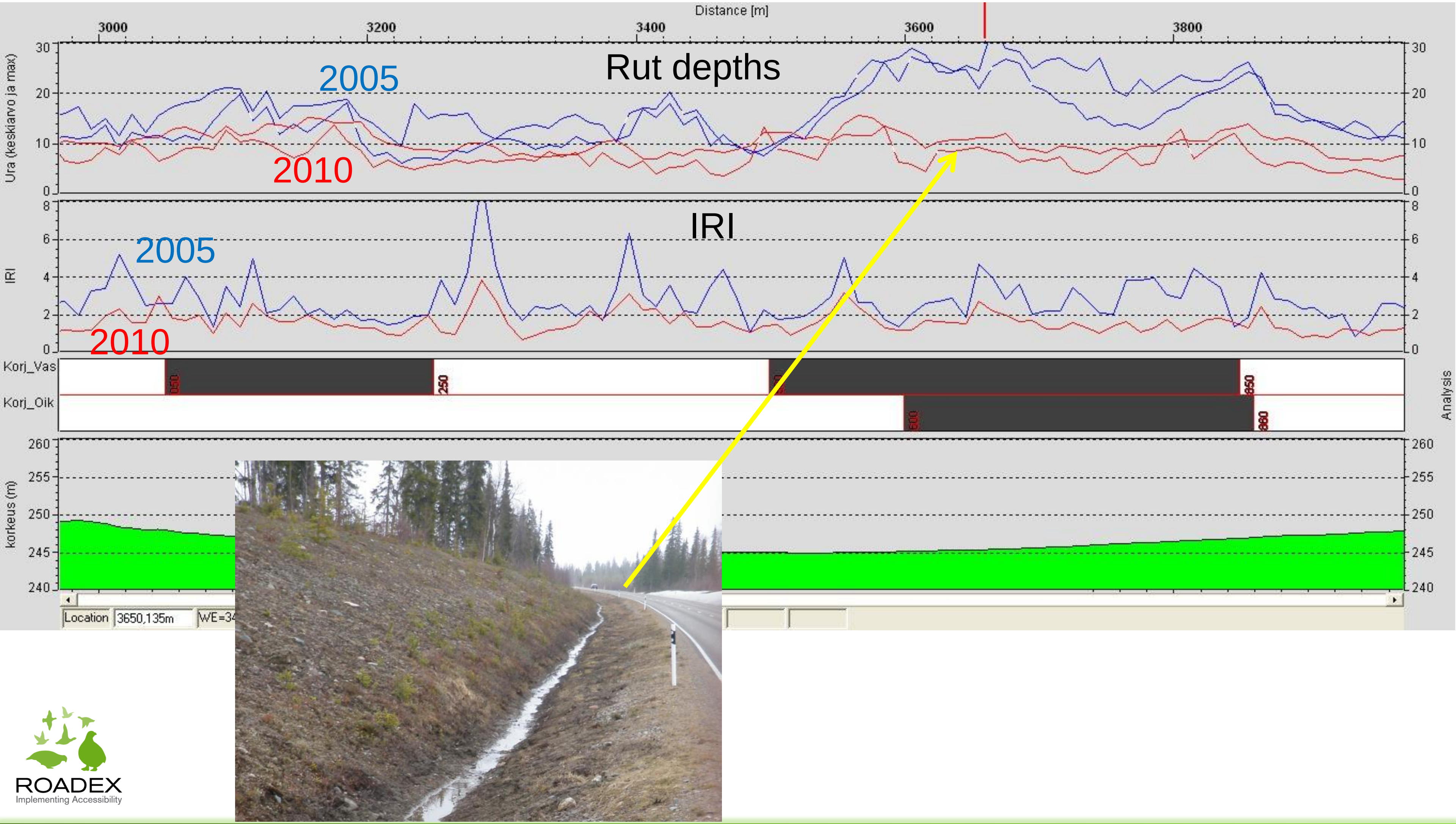
Demonstration project:

Lapland Region, Finland:

- Follow up, how the new drainage policy works in practise in Rovaniemi and Kittilä maintenance contracts
  - Monitoring the condition of special drainage sections
    - How well contractors have done their job,
    - What is the reason for the failures?
  - Has road deteroration rate (rut increase, roughness, pavement distress) really decreased?
    - And if not, what is the reason
  - Problems with Drainage Analysis



Kittilä Follow Up: Rd 80_10, 3000-4000 m



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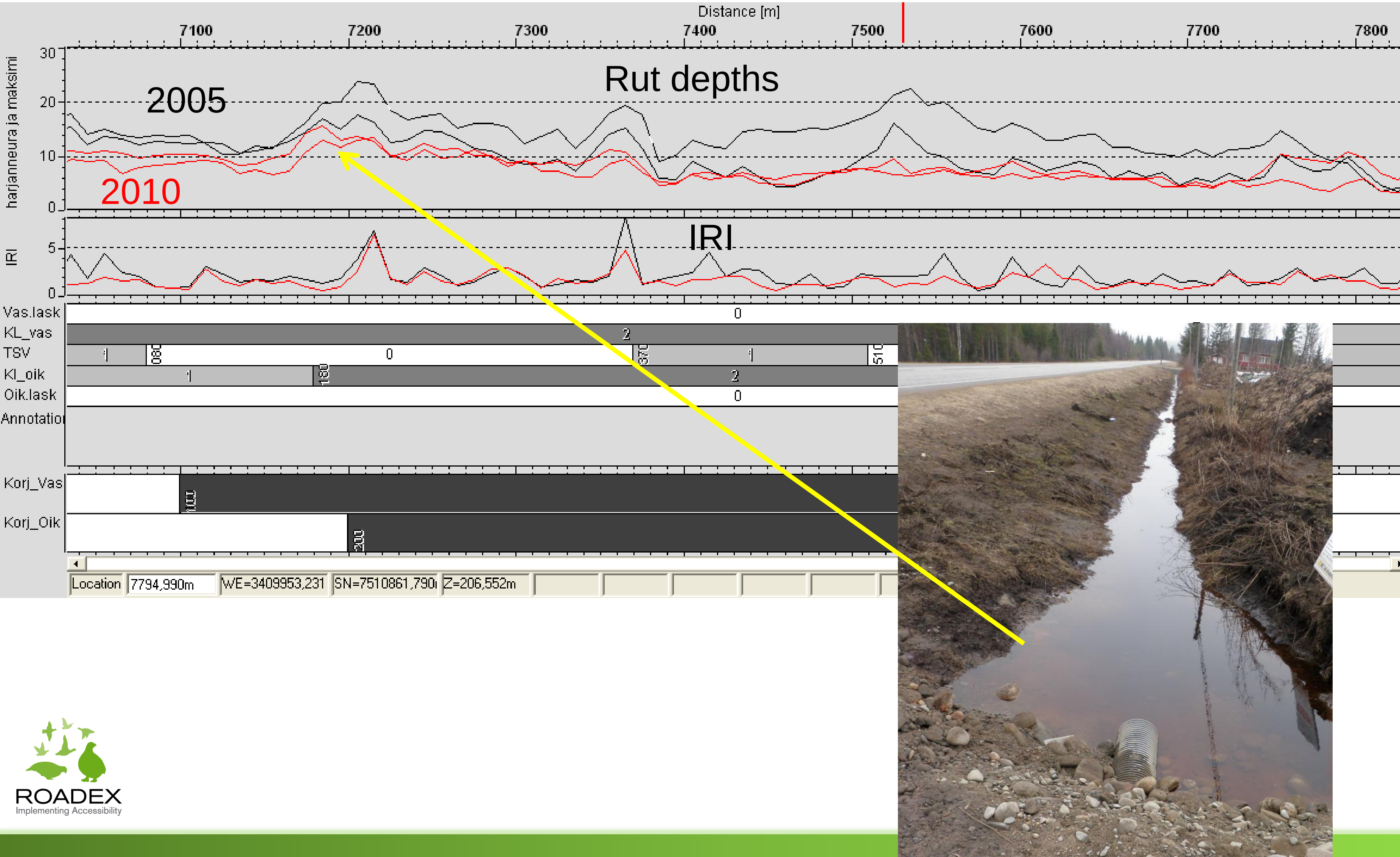
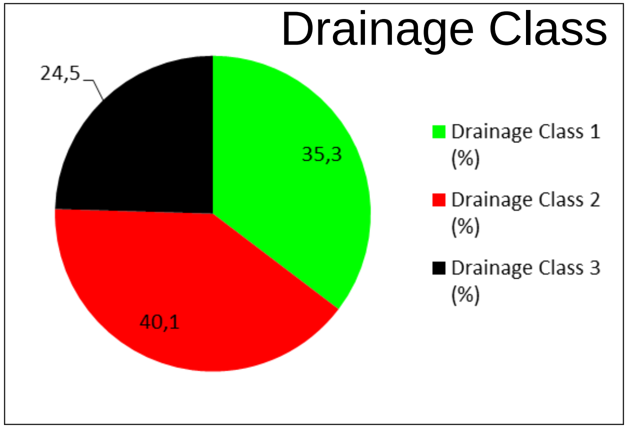
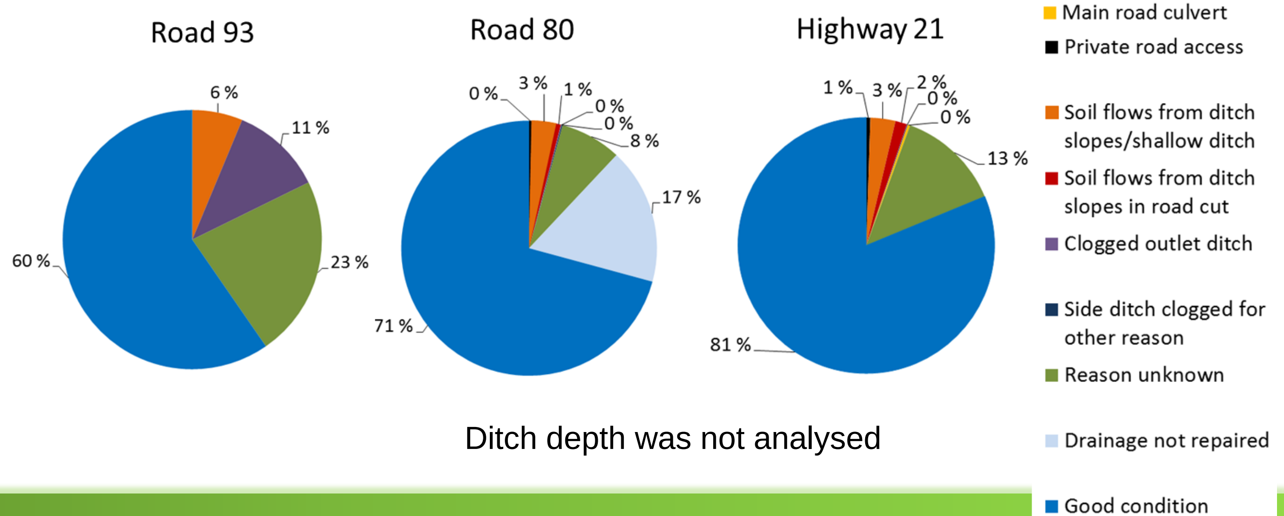
Kittilä Follow Up: Rd 80_10, 7000-8000 m



Condition of Kittilä Special Drainage Maintenance Sections



Increased Rut and IRI and the Reason for that.



Ditch depth was not analysed

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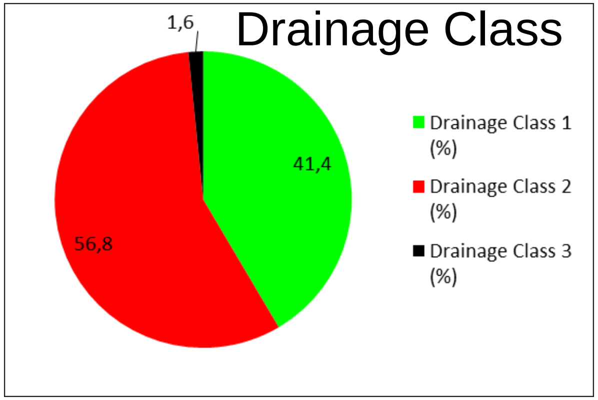
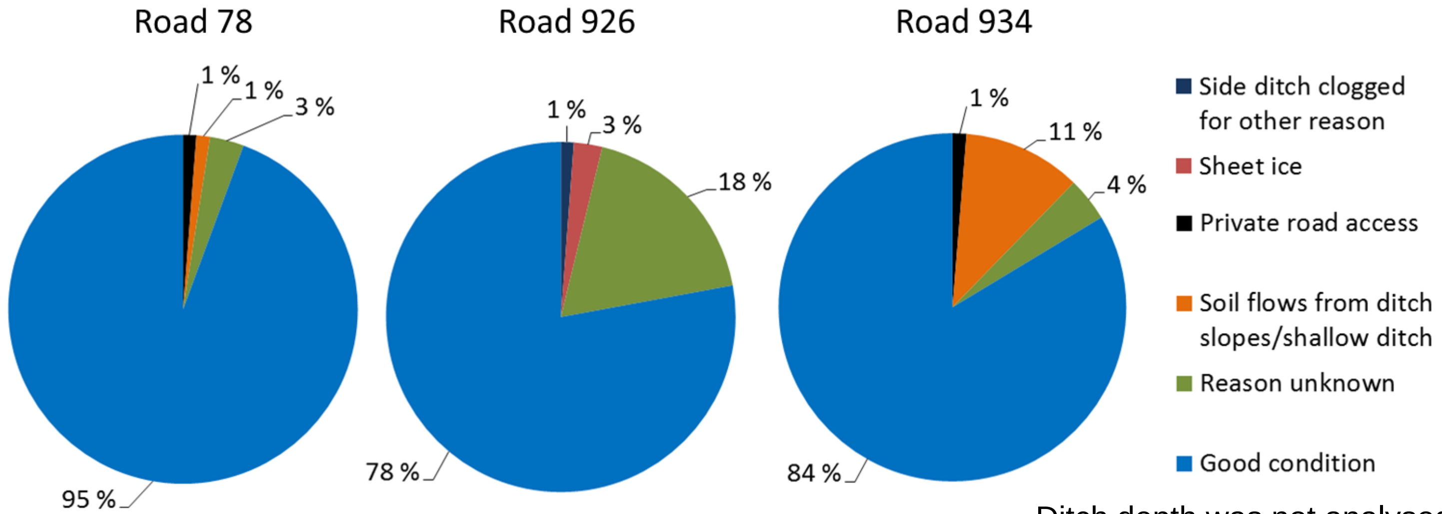
Condition of Rovaniemi Special Drainage Maintenance Sections



Increased Rut and IRI and Reason for that.

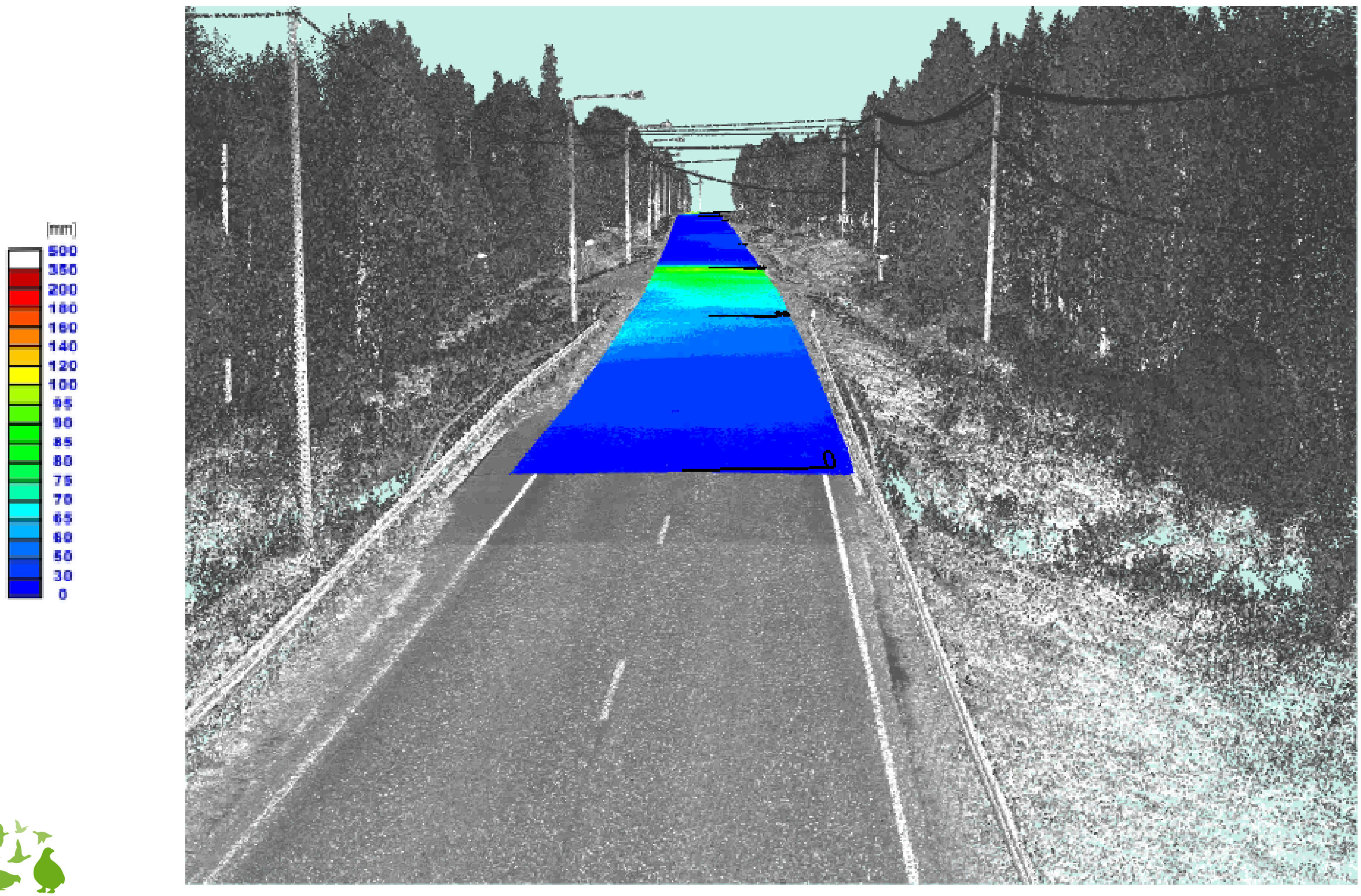


Ditch depth was not analysed

Rovaniemi follow Up: Rd 934 / 3-4

Special problem: Clogged Private Acces Road Culverts

Special problem: Clogged Private Acces Road Culverts



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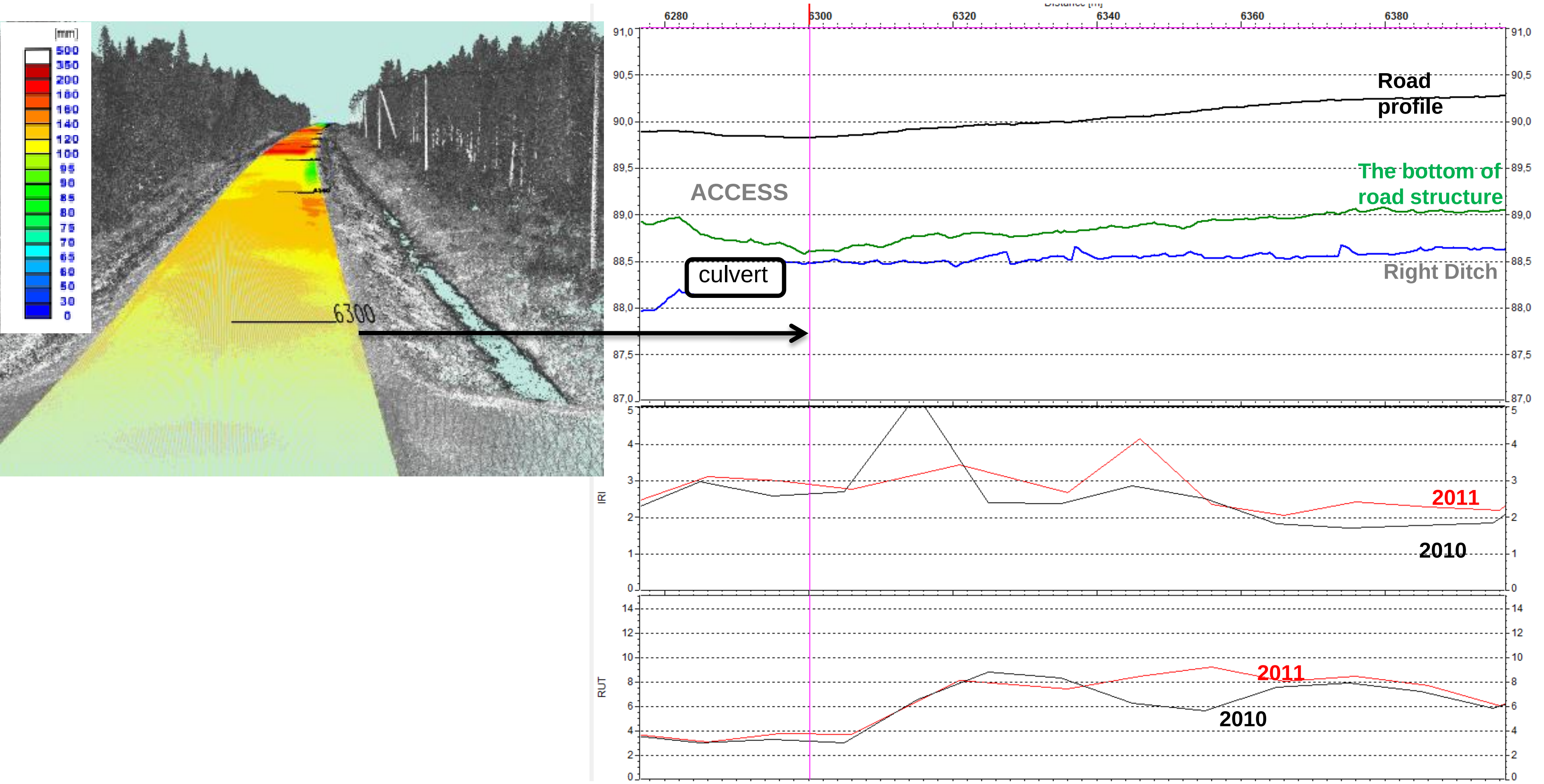
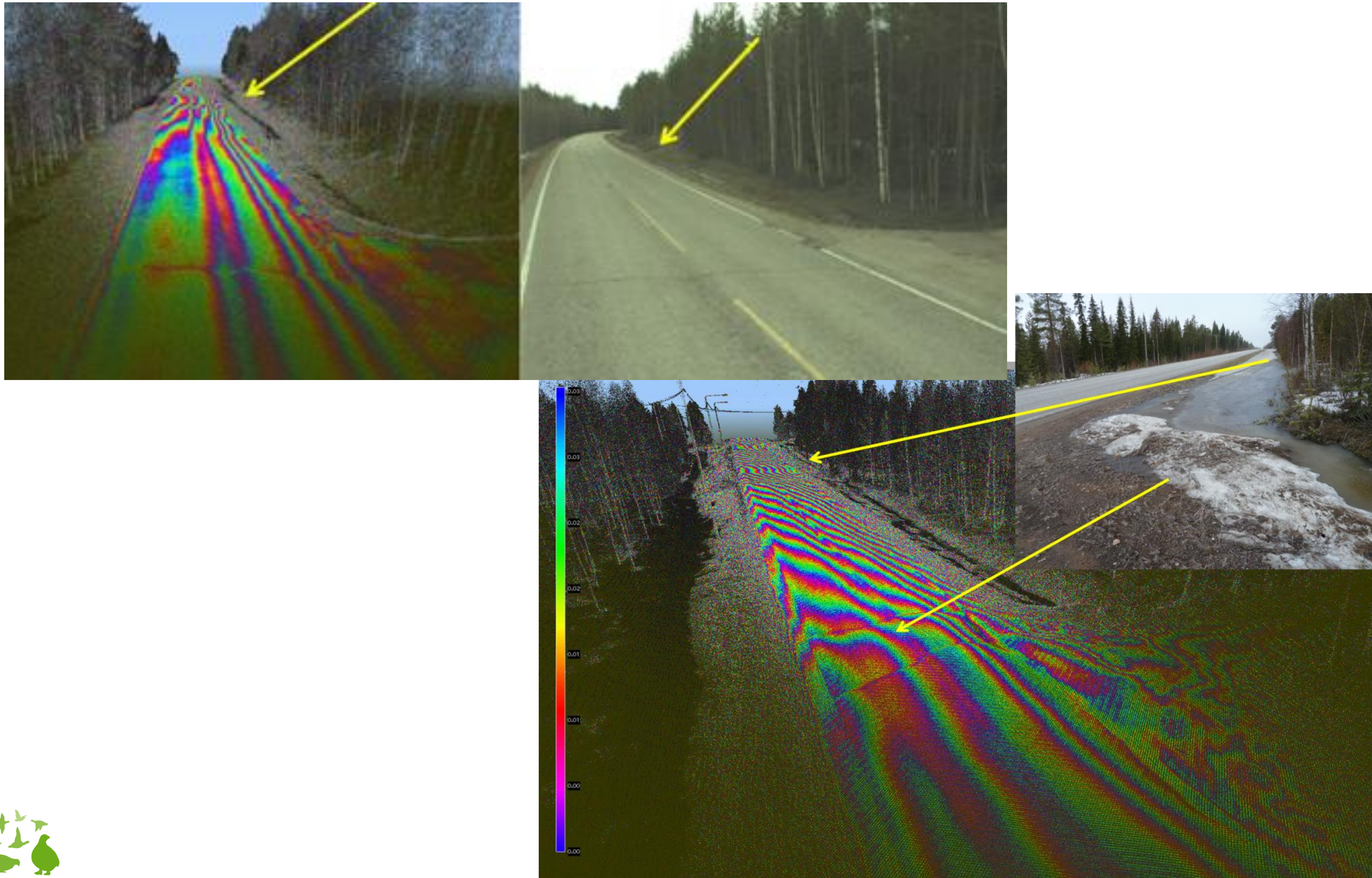
Implementing Accessibility

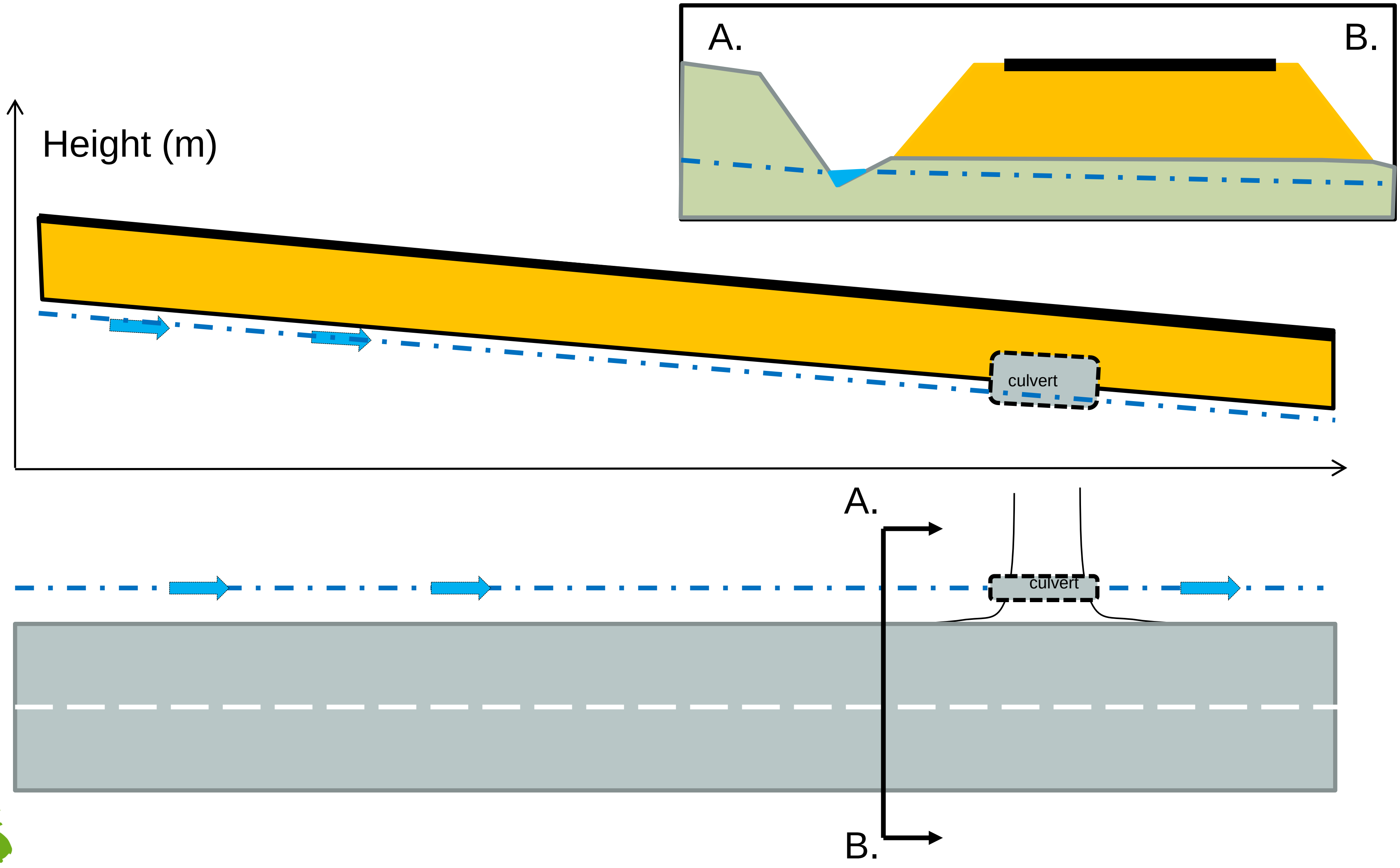
Special Problem: Private Acces Road Culverts



Special Problem: Private Acces Road Culverts

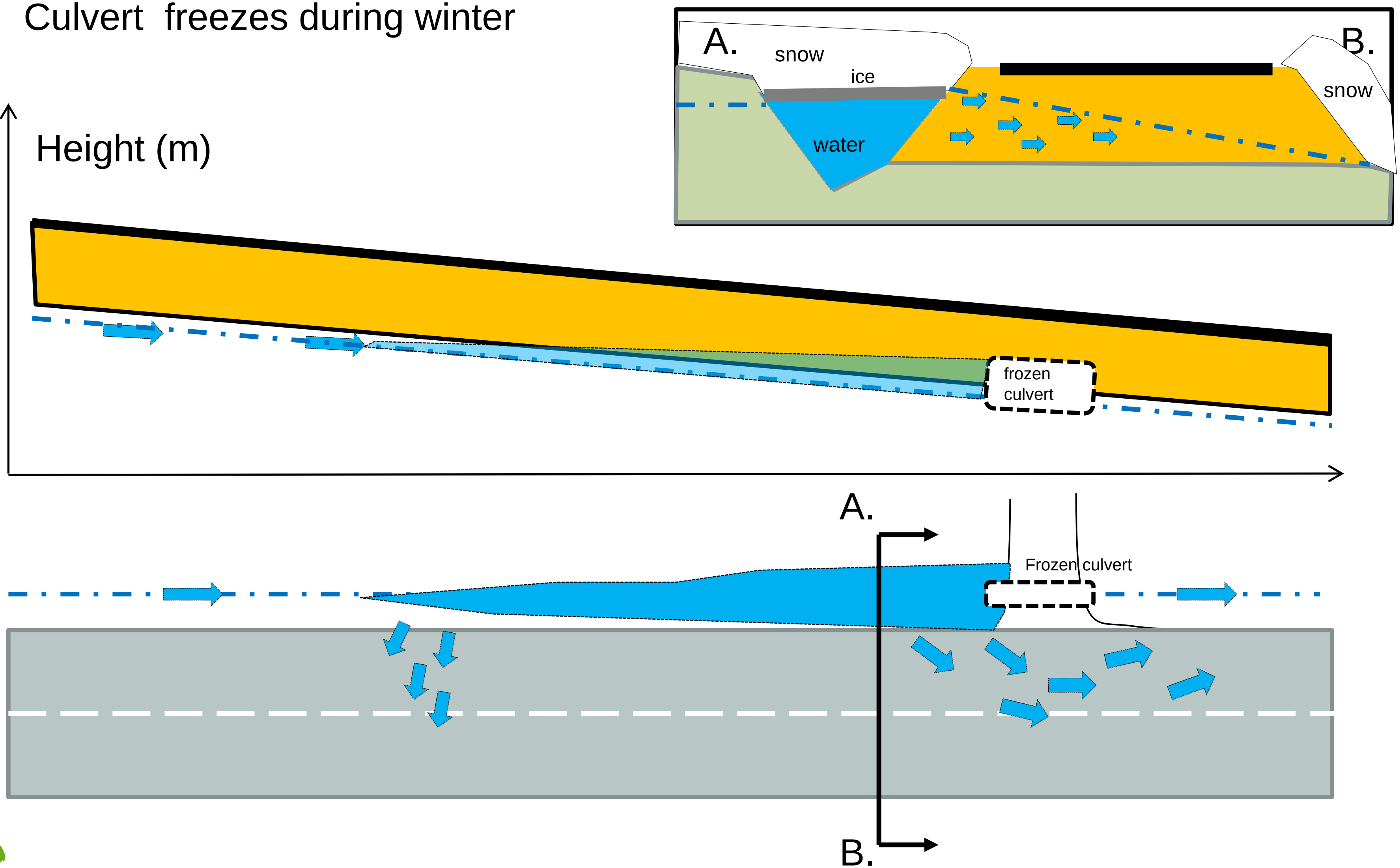


Problems Caused by Private Acces Road Culverts

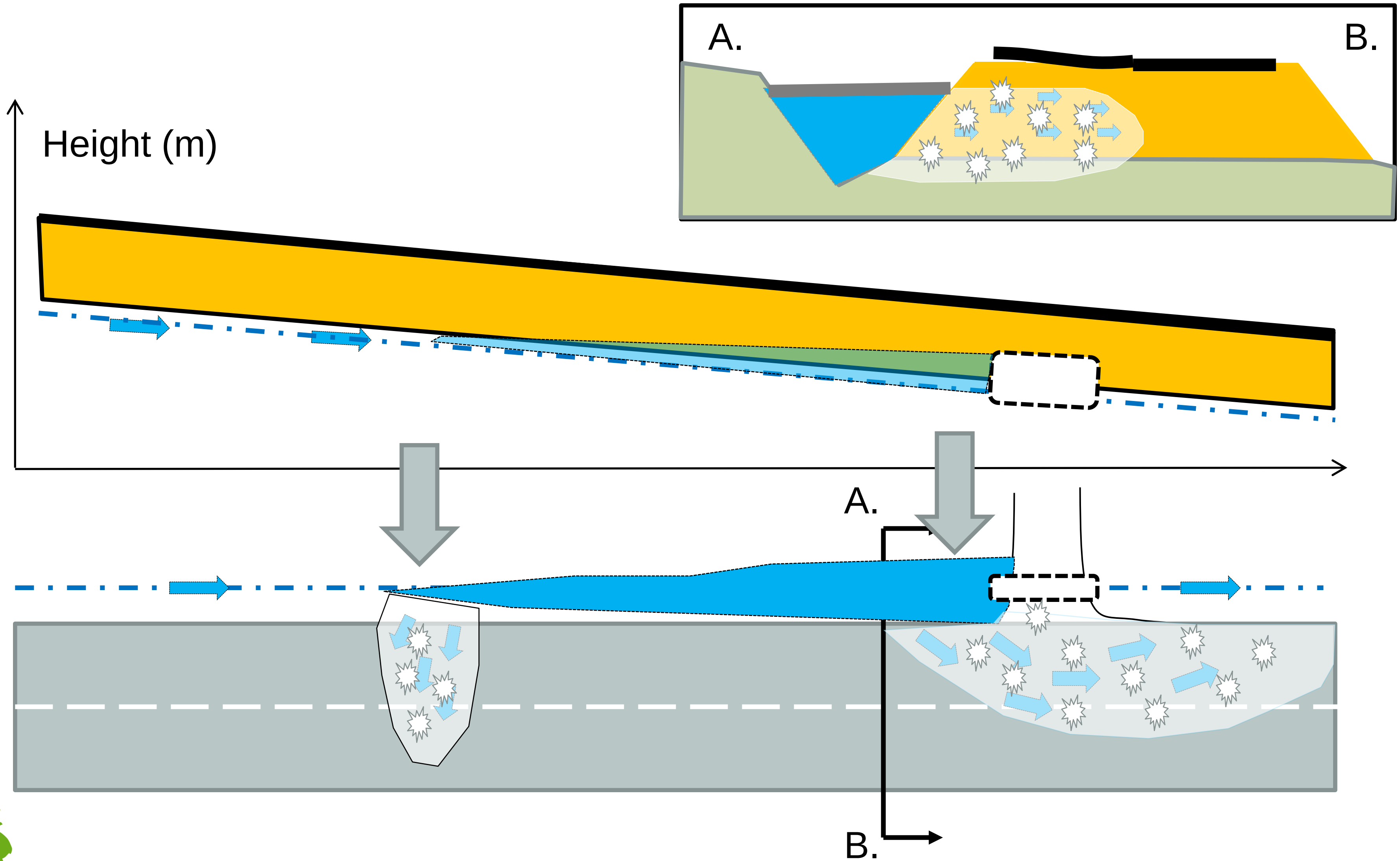


Problems Caused by Private Acces Road Culverts

Culvert freezes during winter



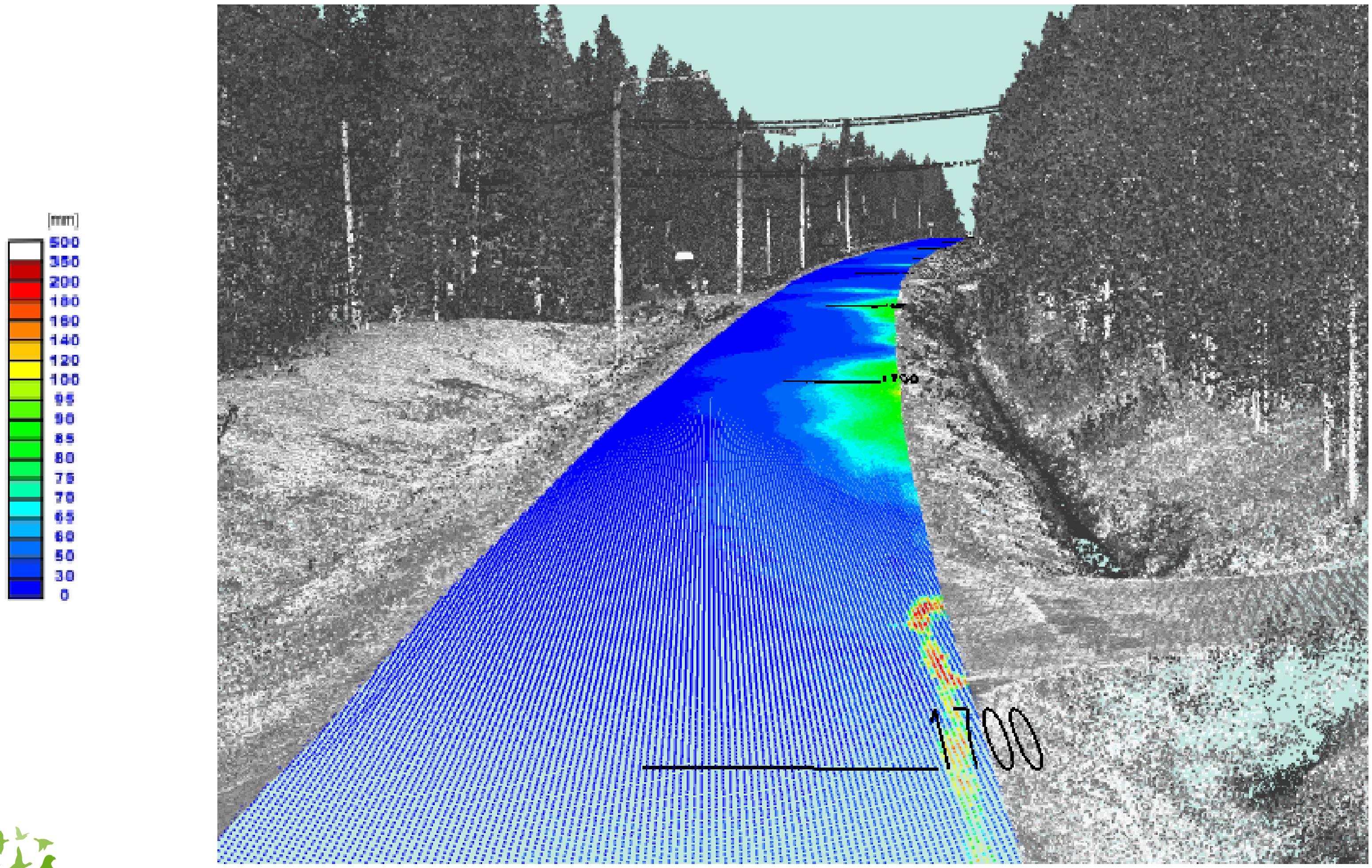
Problems Caused by Private Acces Road Culverts



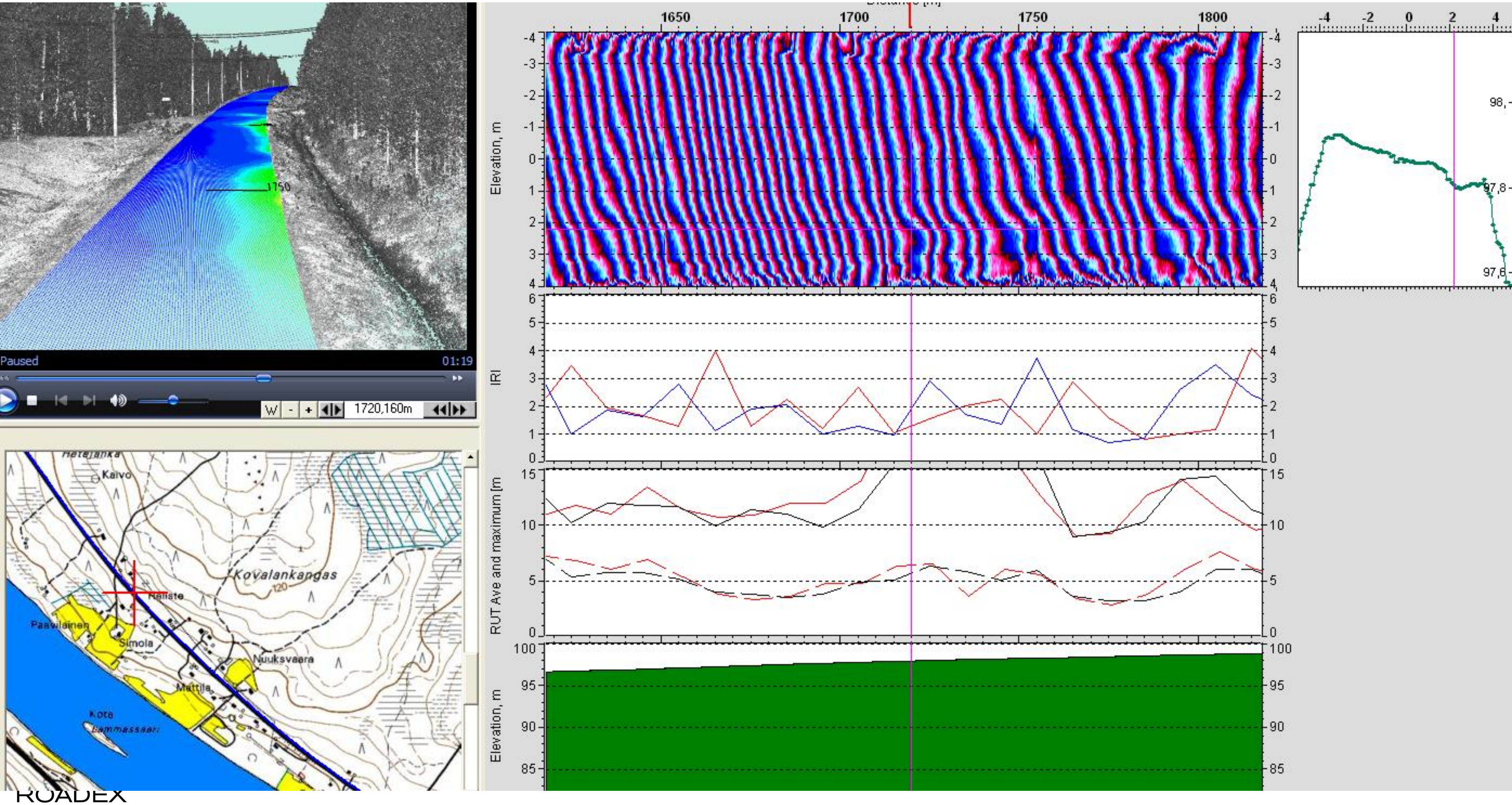
Special Problem also on Gravel Roads: Private Acces Road Culverts

Formation of Ice Lenses Under Road at the End Point of Flooded Ditch

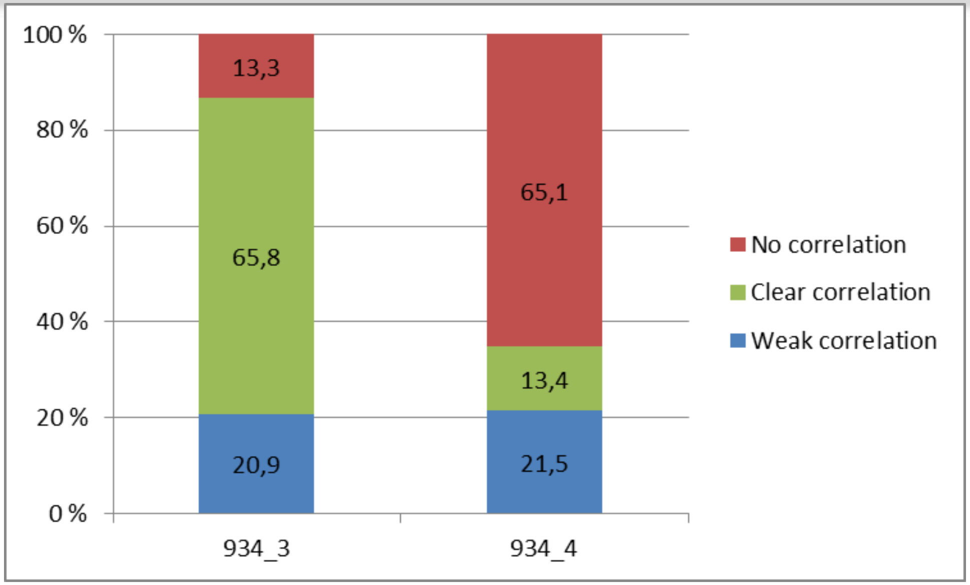
Special Problems Unstable Ditch Slopes

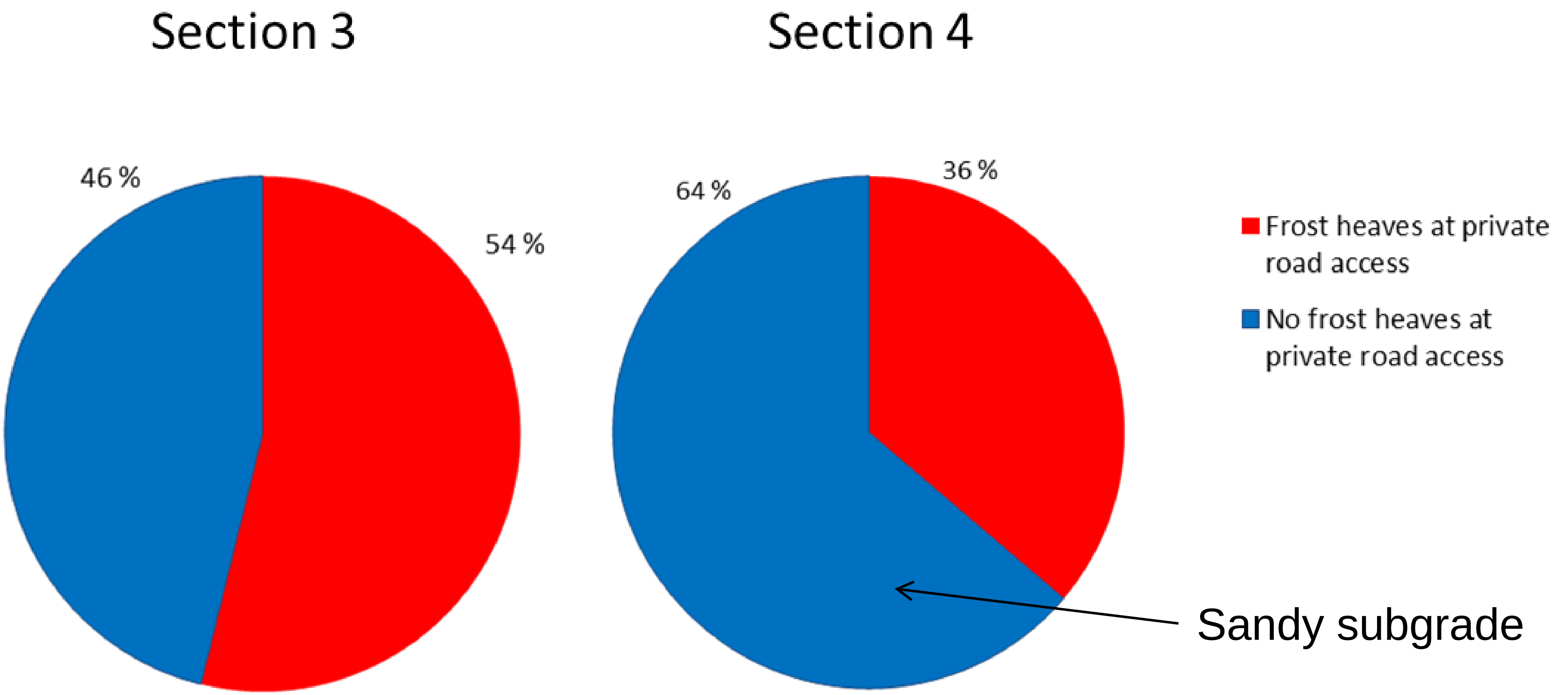


Road 934 section 3, 1740 right



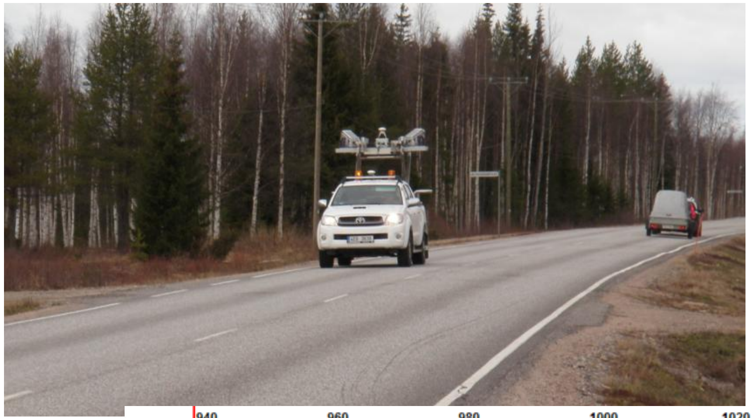
The Role of Private Access Road Drainage Condition and Pavement Life Time

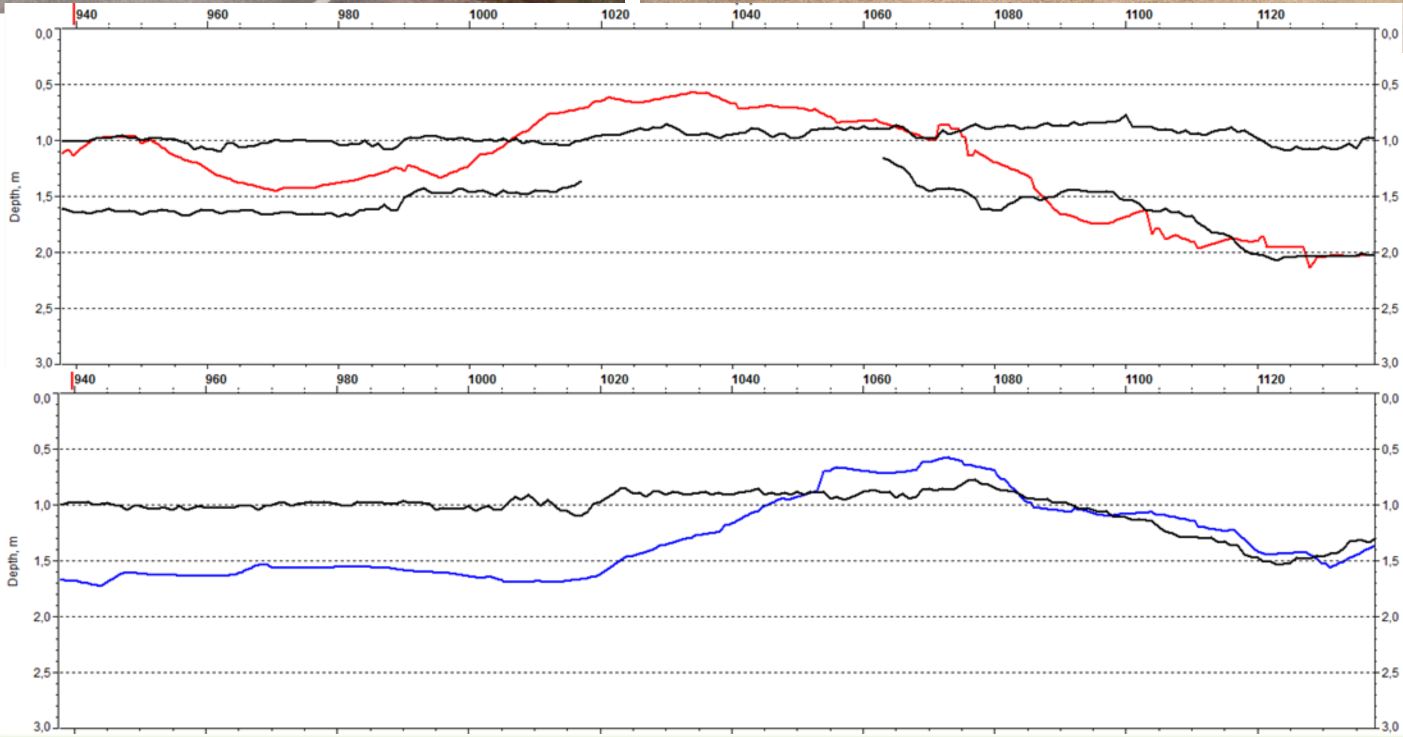




Special Drainage Problem – Sheet Ice

Special Drainage Problem – Ditches too High





The bottom of road structure

Embankment

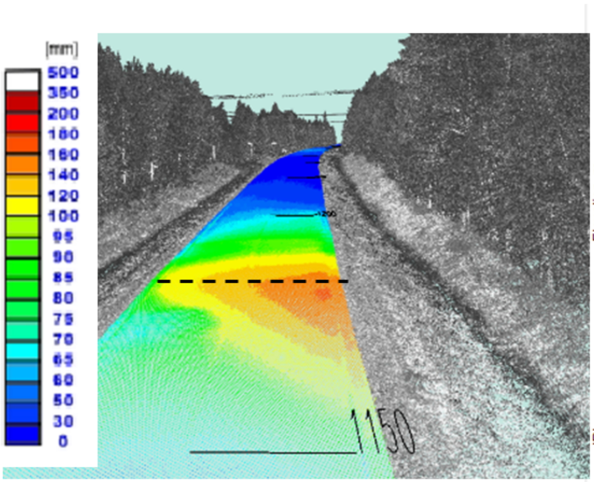
Red line: The bottom of left ditch

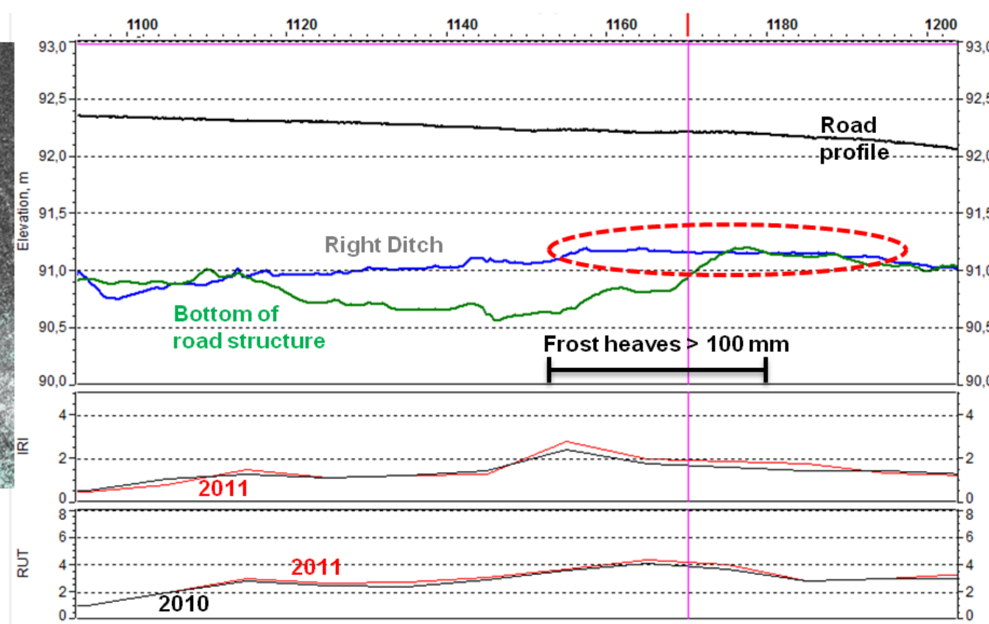
The bottom of road structure

Blue line: The bottom of right ditch

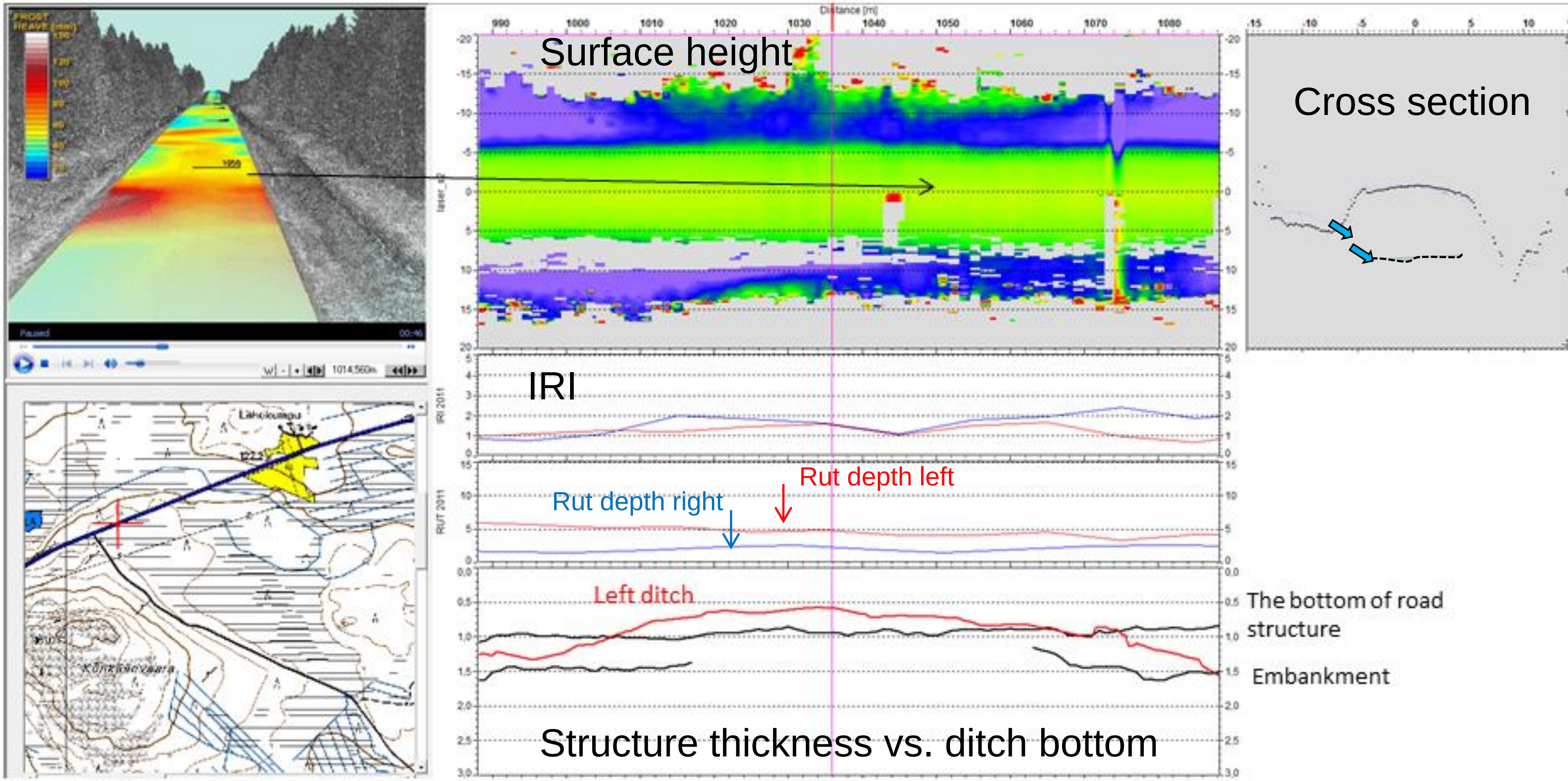
Special Drainage Problem – Ditches too High

	Section 3		Section 4	
	Right Ditch (%)	**Left Ditch (%)**	**Right Ditch (%)**	**Left Ditch (%)**
Ditch bottom level is > 0,3m deeper than bottom level of road structure	46,9	45,9	46,9	58,7
Ditch bottom level is 0-0,3 m deeper than bottom level of road structure	21,1	29,9	30,6	23,7
Ditch bottom level is > 0 m higher than bottom level of road structure	32,1	24,2	22,6	17,7

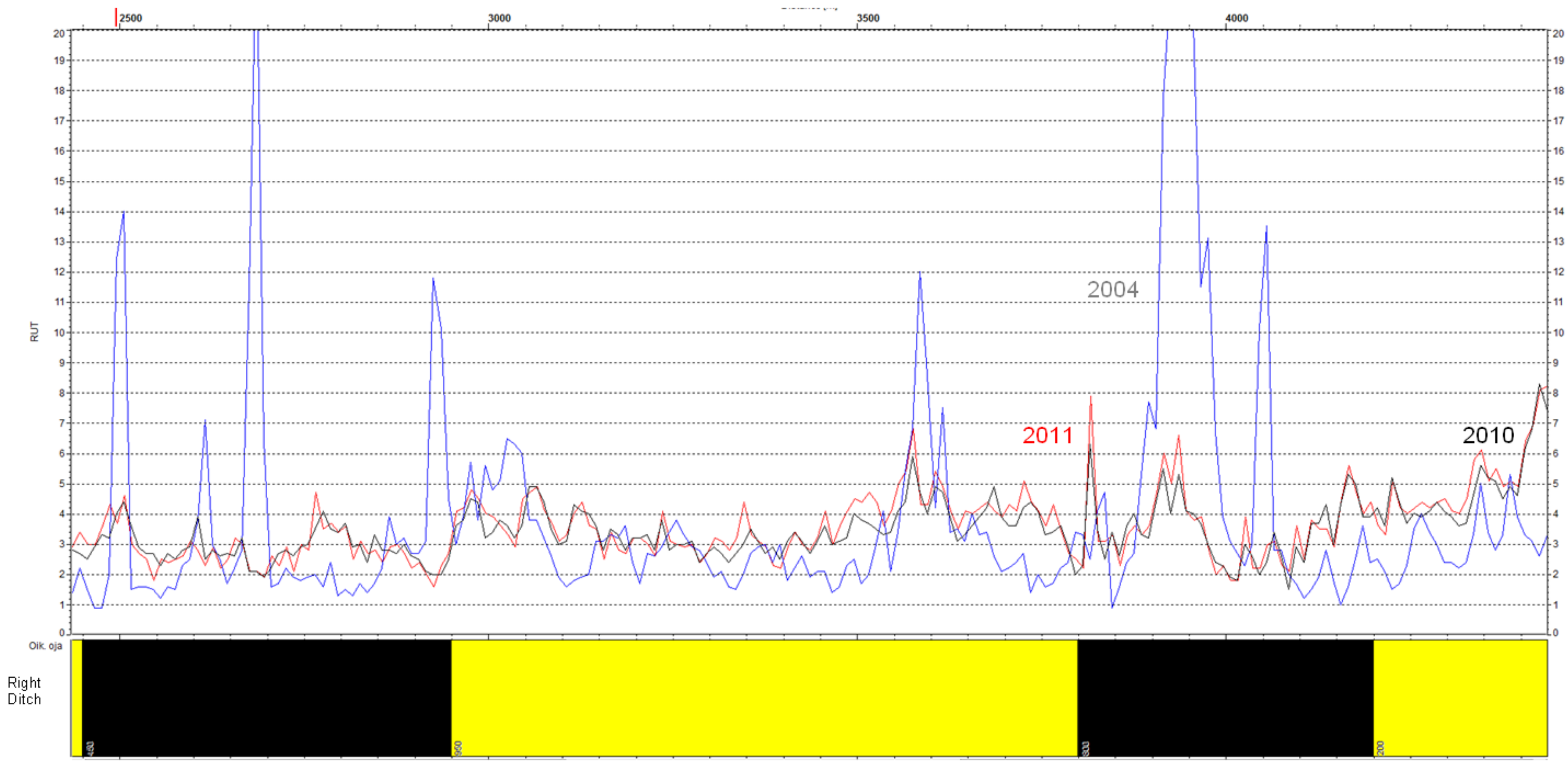




Ditch Condition is a Problem also on Main Roads – Example of HW4



ROADEX Drainage Analysis in general showed problem sections, but more sections could have been selected, special problems were roads with recently improved drainage



Conclusions (1):

- Poor drainage is causing MAJOR problems in all ROADEX countries and better maintenance is even more important than earlier were evaluated
- New mobile laser scanner results really show the importance of good drainage maintenance
- In test road 934 > 50 % of the frost heave problem can be related to private road exit and their poorly working culverts
- Poor access road culverts cause also collapse of ditch slopes and further problems with roads

Conclusions (2):

- Verges are causing problems in all ROADEX areas and should be always removed
- Even small ponding in ditches may cause problems
- Narrow (sharp) ditches cause problems
- Sheet Ice is causing major frost heave and deformation problems in road shoulders => traffic safety issue
- Visual drainage evaluation is not enough accurate and too subjective to enforce maintenance contractors for actions

New Ideas:

- From visual inspection to objective drainage condition surveys:
  - 1. Phase GPR + Laser Scanner => target ditch bottom level
  - 2. Phase: Improvement
  - 3. Phase: MonitoringDitch Bottom Level with Laser Scanner
- Monitoring Systems for Verges
- Focus on Private Access Road Culverts:
  - Road owner need to take responsibility
- Preventing Formation of Sheet Ice:
  - Locating sheet ice sections
  - Installation of heating cables and solar panels
  - Focusing on the ditch form (wider ditch bottoms)

And Poor Drainage is Also a Traffic Safety Issue!!